SCHOOL SCIENCE AND MATHEMATICS

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CENTRAL ASSOCIATION HAS A JOB FOR ALL

Recently your president spent a week end with the folks whose labors throughout the year and year after year go so far to make our Central Association successful. They are our secretary, Harold Metcalf, our business manager, Ray Soliday, and our editor, Glen Warner. What a lot of work these men do! Hours of thought and effort every day; details too numerous to record; vexations, worries and trouble. That is not what they said, but that is what one senses when he sees just a little into the conditions they face. Why do they do it? There are several reasons: They believe in the Central Association and in the good it has done and can still do. They believe in you and me as individual members and the good we can do in our communities. Having accepted large responsibilities, they take pride in discharging them faithfully and well. When you and I realize the work involved in making Central Association the power it is, we naturally ask what is my part in this program. Let us briefly refresh our memories on this, as the lawyers say.

If you are one of the few who have not paid membership dues for this year, you can help by taking care of this detail now. If you have not yet pointed out to some fellow teacher the benefits to be gained by belonging to and attending meetings of Central Association, you might do that tomorrow. If you have a good idea that would make teaching more effective for others, you might take time to write it up for the Journal and send it to the editor. If you would like to review a book for the magazine now and then, you might indicate your willingness. If you have constructive ideas for changes in the magazine, drop a line to the editor. If there is an article that you have liked, tell the editor

so, and pass the article along to a non-subscriber as an example of the good things that the Association has to offer. If you enjoyed some speech at the meeting in 1944, you might drop a line to past president Emil Massey at Detroit and tell him so. He also belongs to that large group of men and women whose labors are making Central Association a power throughout the United States.

And here is a final suggestion which you can put into effect to make the Association a success: Make a note on your new calendar to be at the convention in Chicago, November 23 and 24, 1945.

WALTER H. CARNAHAN, *President*

CHAUNCEY E. SPICER
1862–1943

Chauncey E. Spicer, President of the Central Association of Science and Mathematics Teachers in 1915, died on November 25, 1943. He had retired from his position as Assistant Superintendent of the Joliet Township High School and Junior College in 1939 after forty-eight years of service to the community.

Born on January 4, 1862, the son of Mr. and Mrs. Hiram M. Spicer of Otsego County, New York, he pioneered with them when they migrated and settled at Frankfort, Michigan, where his father became a fruit farmer.

His secondary schooling was obtained at Frankfort, and he attended two summer sessions at the Ferris Institute at Big Rapids, Michigan. His college work was pursued at Valparaiso University, the University of Michigan, and Cornell University. His early teaching experience of about twelve years included superintendencies in four Michigan towns.

Mr. Spicer became associated with the Joliet schools in 1891 and was to see through the coming years the development of the present institution, which was begun in 1901. Since his field was physics and he was interested in all natural science, he began the task of making the science department a superior one. When the fourth unit of the building was completed in 1923, the science department increased its laboratory space to its present size. With equipment continually growing, it constitutes a living memorial to the efforts of a true devotee of science. The transition from teacher to administrator was so gradual that

staff members always found Mr. Spicer sympathetic with their problems as teachers and eager to see innovations and progress in materials and methods.

The introduction in 1901 of college courses into the curriculum of the new school led to the establishment of the Joliet Junior College and the acceptance of its credits by the North Central Association. Mr. Spicer once wrote that such steps wer possible because the people of Joliet demanded the best for their youth.

As an administrator Mr. Spicer developed the curriculum, organized the advisory system, and managed the details of the operation of a complicated schedule involving industrial training, high school and college courses. He watched the school increase to five building units with ample space for every type of educational endeavor.

Upon Mr. Spicer's retirement he and his wife were guests of the faculty and he was presented with complete equipment for photography, including camera, projector, screen and film. Later, when again they were guests, he proudly showed splendid Kodachrome slides taken during a sojourn in Texas and in Florida, where the couple vacationed at the old winter home of his parents.

Known for his high purposes and respected for his demand of the best from pupil and teacher, this man whose association with the institution covered nearly a half century, saw it stand up through the pressure and strain of depression enrollments and found satisfaction in the wisdom which provided a department so well fitted for education in science.

One can think of no better expression of the conviction which provided the incentive for his life work than the quotation from Diogenes which adorns the auditorium of the school: ***The Foundation of Every State Is the Education of Its Youth.***

ROBERT L. PRICE
Joliet, Illinois

Without free speech no search for truth is possible; without free speech no discovery of truth is useful; without free speech progress is checked and the nations no longer march forward toward the nobler life which the future holds for man. Better a thousandfold abuse of free speech than denial of free speech. The abuse dies in a day, but the denial slays the life of the people, and entombs the hope of the race.

BRADLAUGH

TRENDS, DEFICIENCIES, AND CHALLENGES RELATED TO GENERAL SCIENCE*

J. S. Richardson
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Any prediction for the future of general science is of necessity based on some of the observable trends from the remote and from the immediate past. Trends sometimes reverse themselves and thus place the person who predicts in a somewhat uncomfortable position. However, if this uncomfortable position is not faced we have neglected our duty in attempting to anticipate and we have been something less than scientific in our unwillingness to extrapolate.

The challenges of war have revealed certain of the weaknesses of our science program. However, if we accept unchallenged the criticisms of various branches of the armed forces and of industry as to our weaknesses, we make the error of permitting someone who is not a student of the problems of education, or even of the problems of society, to attempt to determine our course.

This is not to say that we should disregard entirely the reactions of those outside our professional bailiwick. Education must be able to stand adverse criticism, and has an obligation to society to profit from the constructive criticism offered from any quarter. However, we should bear in mind that many of the criticisms which have been directed at science teaching have come from those who actually have not been concerned with it and who are not familiar with the problems of the profession. To a very great extent, these criticisms have been the criticisms of persons who in the heat of conflict have at least attempted to justify certain of their own shortcomings, and in some instances have been only too happy to attempt to find a scapegoat. We should not disparage the spirit in which certain of the criticisms have been made. Many of them have been made in the best of faith. Certain of them have been made by individuals who are quite competent from a professional point of view. Nor is it suggested that science teaching, particularly at the general science level, has been free from shortcomings. There is perhaps no better time than the present to assess the situation, to attempt to distinguish trends and to set new goals.

The impact of war has revealed what seem to be certain basic

* An address before the Junior High School group of the Central Association of Science and Mathematics Teachers at Chicago, November 25, 1944.

deficiencies. If the treatment seems to be negative for a great portion of this discourse, it will be only by way of securing a basis for some constructive proposals which, in view of the time limitations, may be stated rather briefly and perhaps not too greatly elaborated. The war has revealed, as did another war a quarter of a century ago, our lack of progress in improving the health of our nation. The responsibility for health rests in part on all teachers within the nation. The teacher of general science is in a rather good position to make a definite contribution to this aspect of living.

A second deficiency which is pointed up by the war is the lack of knowledge of basic science in all fields, including health. In many instances, those who have been actually engaged in the prosecution of the war have deplored the lack of scientific training when what they have wanted, at least in part, is technology. Certain schools attempt to produce at least embryonic technologists and in this respect this challenge may have some weight. Technology is based on science and mathematics and therefore, at least secondarily, the challenge may be appropriate. That our students have not learned fundamental science to the satisfaction of not only those who are prosecuting the war but also of the teachers goes without saying. It is interesting in this connection to note that little has been said about the lack to possession of the scientific attitudes, or the inability to apply the method of science as attributes of our graduates. We might infer that our graduates have satisfactorily demonstrated such abilities, or that such attributes are unnecessary for the things that the armed forces and industry want done, or that analysis of the deficiency has not yet revealed this factor.

A third aspect of the challenge is that the graduates of our schools are deficient in the skills of fundamental measurements. This idea is suggested in the brief statement related to technology. Thus, not only the science teacher but the mathematics teacher as well has a stake in the needs of industry and of the armed forces and in the problem as considered from all angles.

The problem is of greater social significance than the immediate needs of the present conflict. We fervently hope that the general science which is being taught now will be used in generations of constructive social and economic activity. Hope, alone, is sterile. Careful study, planning, and action are the order of the day.

In order to speak with clarity concerning the above challenges

and of the ways in which our science program may meet the needs of the society which will follow the war it seems prudent to get before us at least two underlying ideas.

The first of these is that no one can be certain of what our society will be like in the post-war period. We have rosy pictures painted by those who have spectacles with that particular tint. We are led by some to believe that automatic devices and gadgets will reduce the processes of living so that of each day one-half will be spent in our respective ways of earning a living, the other one-half day spent in some leisure time activity—the whole characterized by the pushing of buttons and the turning of switches. Our dreamers have stopped not with this physical side of our lives but have predicted that the schools will be as streamlined as their fanciest gadgets. They see living evolving from an intelligent interaction with the factors of our environment to an automatic control over all factors. The suggestions for our schools include a far heavier reliance upon quick learning than most experienced educators feel can be achieved successfully. We would be more than shortsighted if, on the other hand, we were to assume that our mode of living will be unaffected by the rapid social evolution which war brings about. Desirable redirection for our general science should be determined in the light of an evolving society.

A second idea, which is an assumption, is that our general science courses are determined very largely by the textbooks used. That there are exceptions to this goes without saying, but we know that our general science is taught to a very great extent directly from the textbook. From the texts we can gain some understanding of recent trends, and through the text we can at least partially influence the future of general science.

Let us try to generalize upon certain of our weaknesses in general science. Perhaps the greatest of these is that the field of general science has never been clearly defined. It is unnecessary to do more than mention the historical evolution of general science. It was originally made up of some of the more elementary subject matter from the fields of botany, zoology, physics, and chemistry. It was gradually expanded as time went on with related materials from physiography, geology, physiology, health, astronomy, conservation, and consumer science. There has also been a reorganization of materials already included to give such studies as transportation and communication, but the result of all of this has been that our efforts have been in

part academic and in part social. Too often we have been unable to adapt the academic to the social function, but tradition has been strong and our courses retain unfunctioning material.

The growth of the field has been determined by a type of leveling process the evolution of which has been conservative. Each new author apparently has determined his scope of topics for inclusion by arriving at an average of the inclusion of topics by other authors. Certain brave efforts for change are noteworthy but often they have been relegated to the position of last chapters, to be included at the end of the year if there is time left over. Too often there has not been. Because such brave efforts have been few, their effect has been perhaps less than the mathematical average suggested as each new author has studied the frequency of topics selected by previous authors in going about his writing. A further difficulty in the definition of the field has been brought about by the fact that without being too certain about what we should include in a one-year course in general science we have developed a three-year sequence. The results from that have not been too happy in many cases. Various efforts to prevent overlapping and to conserve the interest of the child have been made. A type of spiralling process was one such offering. However, we still have overlapping, loss of interest, and some feeling of confusion with reference to the function of each of the three years of science in grades seven, eight, and nine.

The field has had little functional relationship with other courses in sequence. For example, in general science we feel that we have been justified in an approach through living things and yet to a very great extent we have been unable to secure a functional relationship between the general science and the biology which follows in the usual order of courses. Corresponding comments might be made concerning physics and chemistry in subsequent years.

At the same time, general science has not been designed as a terminal course in science even though it has actually been that for thousands of students. In 1934 15 per cent of all public school students were in general science, 12 per cent in biology, 6.3 per cent in chemistry, and 5.2 per cent in physics. Inasmuch as general science is not a prerequisite for physics and chemistry in many schools, and, further when we consider the great student mortality at the end of the ninth grade, we see that it has become a terminal course for a very large number of students.

There has been, of course, some effort to develop a type of terminal general science course for seniors. This has taken the form of Advanced General Science, Senior Science, etc.

A second major weakness of the field is that we have been preparing teachers in physics, chemistry, and biology, and these teachers, it has been assumed, have at the same time been prepared for general science. For example, in one state the State Department of Education recognizes a comprehensive major in science consisting of forty hours selected from the various academic fields, but as provided in most institutions for teacher education, it consists of separate academic courses which in themselves are not functionally related one to another and for which unfortunately the schools and colleges of education do not provide adequate professional integration. The preparation for such certification becomes an unrelated composite and is not in any sense a professional integration which would enable the prospective or in-service teacher to meet the needs and serve the functions of the general science course.

A third major deficiency in the general science study is that the teaching of general science is considered to be a stepping stone to academically more advanced work or is a necessary evil which accompanies such teaching, to be discarded as soon as a new section of chemistry or physics can be created. A study of the records of teaching experience will reveal that the pattern in general is for a teacher to be employed in the junior high school and then to advance for salary or prestige reasons to the senior high school and to deprive the school of the benefits of the experience which he has gained. Other harmful effects of this migration are a lack of interest in the field, and insufficient effort to develop an integrated program of science.

What are some trends in general science to which the foregoing problems may be related?

It is easy to start with a look at the textbooks themselves which, as was mentioned, determine to a very great extent what is done in the courses. Study reveals that we have stopped making general science texts with more pages. We seem to have reached a saturation point so far as number of pages is concerned. That may have grown out of a realization that only so much can be done within a given period of time. Investigation reveals also that this has been accompanied by no significant increase in the range of topics. It is true that there has been a certain shift of emphasis in some of the most recently published

texts. In the functional areas of transportation and communication we find more attention given to the applications of these functions to war. That these will be removed following the war seems a fair prediction.

Study of the texts reveals also that there is a tendency to larger pages, large type, and larger pictures. In the latter particularly, there is a decided improvement. In certain texts the use of bled pages utilizes the margins. This adds a great deal to the technical quality of photographs. This has been accompanied by a decrease in the number of those photographs which occupy less than one-fourth of a page, which in themselves were often of limited value. There has been a significant increase in the number of photographs of a full page size, and in some instances more than full page, and of those of more than one-half page size. That our knowledge of visual education is having some effect seems to be self-evident. Investigation does not reveal any significant trend in the nature of the photographs except in certain instances where more emphasis is given to photographs of children's activities in the revisions of the texts. The same comment applies in general to drawings.

There is indication of increasing encouragement of pupil activity. Texts are suggesting more and more things for children to do. The laboratory manuals are being made somewhat richer in their suggestions. Study of the suggested activities shows some attention to child interest and concern, and less of direct borrowing from biology, chemistry and physics. There seems as yet to be no good quantitative measure of the interest-provoking quality of materials prepared for science use. There is still the quarrel as to the appropriate point at which suggested laboratory or demonstration work should be included. The question is well known—whether it is psychologically good to include suggestions or directions for laboratory work with the textual material or whether these should be held to the end of a chapter or unit. There is some evidence that more are going into the text.

There is some indication that where there have been three-year general science sequences we are moving toward a one-year general science course. As yet this has not been of widespread proportion; but there are some schools that are now looking with disfavor upon the seventh and eighth grade general science, and we find the authors of textbooks rising to meet this shift. Some are rewriting their three-year general science texts into a one-year volume.

A study of the statistics of enrollment in the various courses in high school reveals from 1922 to 1934 a gradual decrease in the percentage of those enrolled in general science. One may attempt to explain this by pointing to the increasing number of those attending high school. If general science is as important as we feel that it is, why should it be losing ground on a percentage basis? In this same period (1922 to 1934) our society experienced an unprecedented technical development. If science is of value in understanding and controlling our environment the need for it is increasing, but the percentage of those being prepared to meet this need is decreasing.

We are now experiencing a trend which is more recent—the loss to the profession by those who have left for the armed forces or industry. We have all been appalled by the shortage of qualified teachers. Perhaps no high school field has been harder hit than science. The cessation of the war will see the return of a portion of the science teachers—what portion it is hardly safe to predict. Meanwhile we are preparing few teachers in all fields combined; in science the dearth seems most pronounced. It seems safe to venture that another decade will pass before we have many science teachers leaving our institutions of higher education to teach in our schools.

In the light of the deficiencies and trends which have been mentioned certain challenges confront us.

First of all, we need a revised concept of the social function of science. Nowehere is this more necessary than in general science, where the percentage of those enrolled is the highest of all the sciences, and where, in the high school, the total enrollment per grade is greatest. There is no implication that this problem has been neglected entirely. Some worthy efforts have been made. We need to study continuously not only the content of the field but also the problems of teaching. Such studies must be made in the light of the functions of science in an evolving society.

A particular aspect of this is in determining what science is significant from a terminal point of view. This is not to say that only that science which is terminal should be included in a general science text. However, we cannot escape the fact that for many children general science is the only experience in the field. This places a heavy responsibility on the course; one which can be discharged only on the basis of extensive research. This research includes experimentation with classroom procedure on a scale and with thoroughness and accuracy hitherto unknown.

An example may serve to illustrate one type of practice that we need to know much more about. There seems to be merit in reversing what has been the traditional approach to the learning unit. Two of our great teachers of the past have counselled on this point. The one said, "Study Nature not Books"; the other, "Learn to do by doing." But we have not yet learned much about true exploration as a part of the learning process. It seems somewhat paradoxical that a field based so fundamentally on the experimental method of science makes so little use of it in the learning process. The use of the laboratory to illustrate and verify is not denied, but as yet we have done little with the laboratory in its more important function—exploration.

As was mentioned previously, teacher training institutions should prepare teachers of general science by organizing academic and professional courses appropriate to the field. One could make an example of a well known institution of higher education which devotes six hours of special methods to the teaching of arithmetic in the preparation of elementary teachers but makes no professional provision whatsoever for general science. The preparation of teachers of general science is supposedly supplied by a two-hour special methods course in physics and chemistry combined, or a two-hour special methods course in biological science. This is not a proposal that more special methods courses will provide the answer but simply a statement that there is evidence that institutions have not regarded the professional preparation of general science teachers with any seriousness. The professional attention should be manifested in the range, quality, organization and integration of the content of the academic courses offered. Such materials should be selected on the functional basis of life use. The learning situations in the institutions for teacher preparation should in themselves be based on the experimental approach.

Finally, there is real need for a study of the sequence of our science offerings. Our assumption seems to have been that one function of general science is to explore briefly each of the various sciences and on the basis of exploration to expect that, first, the material studied will become functional, and, second, that it will serve as a basis for biology, physics and chemistry, although not necessarily a prerequisite to them. This assumption is challenged by the problems which general science now faces. The entire range of offerings in science in the high school should be studied. Sequence, and the avoidance of repetition and over-

lapping are of importance in this connection. But the formality suggested by such organization should not be such that the growth of the individual is impaired. The implication of this in practice is a much smaller pupil-teacher ratio, so that individuals may be taught as such.

There is a possibility that our science should be generalized after our specialized courses have been studied. As such, it would not be the general science which is now offered, but would partake of an interpretative science which would enable the individual to integrate his learnings in the various areas, and to make them more directly applicable to the problems of living. The use of such a series of culminating experiences would not preclude a general science course in the junior high school. A year of general science in the eighth grade would be followed by biology in the ninth grade; then two years of physical science in the tenth and eleventh grades with a final year of general science in the twelfth grade. At the same time provision might be made for the student to follow up more specialized interests which would utilize his achievements from several fields.

These proposals may sound somewhat visionary and impractical. In the years following the present conflict it seems highly probable that education in all its aspects will have critical challenges directed to it. We need now to re-examine, to experiment and test, to study and to plan so that the profession may meet such challenges and make the maximum contribution to society.

CHEMICAL INDUSTRIES WILL SPEED UP RESEARCH WITH END OF WAR

Chemical industries will start greatly increased research programs "to make up for lost time" just as soon as their war researches end, Dr. Elmer K. Bolton, chemical director of E. I. du Pont de Nemours & Co., predicted in accepting the Perkin Medal of the American section of the Society of Chemical Industry.

This postwar research to improve the American standard of living will be handicapped, however, he declared, by a serious shortage of well-trained chemists which will be felt for a number of years.

"Since World War I, the chemical industry has made remarkable progress," Dr. Bolton said, "due in a very important measure to the friendly attitude of the government toward research. Granted a continuation of this attitude, organized research will go on creating new products, for what remains to be done is far greater than anything that has been accomplished in the past."

DRAWING WITH RULER AND PAPER

ADRIAN STRUYK
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A method of drawing certain rectilinear figures without using the compasses is considered in this article. Although chiefly recreational in character the matter involves features that are useful in the plane geometry classroom. The method makes use of paper as an instrument. Since its function is to transfer lines from one place to another the paper instrument may be called a carrier. Paper on which a desired figure is to be drawn may be called a work sheet.

A suitable form of carrier is an inch wide frame made by cutting a 4″ by 6″ rectangle out of a 6″ by 8″ rectangle. The word "rectangle" here does not imply painstaking construction. It is sufficient if the edges of the instrument are smooth and sharp —they need not be straight. In use the carrier is placed upon the work sheet. Lines on one can then be transferred to the other by means of the ruler. On the carrier a line is determined by two "traces"—short segments—on different parts of the frame, and will be so designated. The word "line" then applies only on the work sheet. Most drawings require that it be possible to make two traces on the carrier to coincide with a line on the work sheet. Such traces must meet the edges of the carrier. They will be called indexes.

Construction of a parallel to a given line through a given point is easily effected. On a work sheet take a line m and a point P not on m. Lay down a carrier so that P and a segment of m appear in its opening. Draw, without moving the carrier, indexes of m and traces of any two lines through P. Translate the carrier so that m and its indexes remain in line. Draw the lines determined by the traces on the carrier. These lines intersect at a point P'. PP' is parallel to m.

The sum and the difference of two given angles are also easily obtained. Let angle ABC and angle DEF be given. Frame angle ABC with a carrier. Draw indexes of BA, traces of BC. Move the carrier so that the indexes of BA coincide with ED, and draw traces of EF. Rotate the carrier through angle DEF, making the indexes coincide with EF. Draw traces of ED. On the work sheet we can now draw two angles, one determined by the traces of BC and EF, the other by the traces of BC and ED. One of

these angles is the sum, the other the difference, of the given angles.

An obvious use of the carrier is duplication. Construction of congruent figures—polygons, sets of points, special groups of lines—offers no difficulty. Place a carrier so that it frames the given diagram, and then draw a number of traces sufficient to enable reproduction elsewhere.

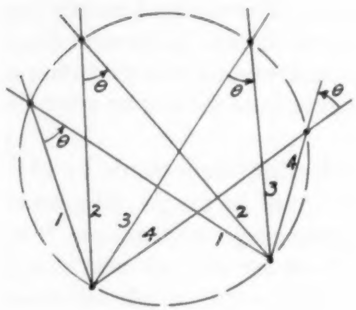

FIG. 1

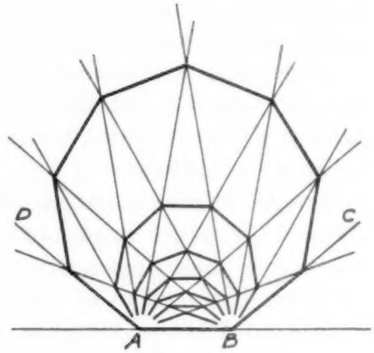

FIG. 2

By means of two congruent sets of concurrent lines several concyclic points can be obtained, as shown in figure 1. The intersections of corresponding lines of the two sets, and the two centers of concurrence, are concyclic. Each pair of corresponding lines form an angle (θ) equal to the angle through which the carrier was turned.

Regular polygons, too, can be drawn by using two congruent sets of concurrent lines or rays. For an n-gon such a set of rays consists of an angle of $180(n-2)/n$ degrees divided into $n-2$ equal parts. Let angle DAB and angle ABC be two such angles so divided. The rays intersect each other at many points. The outermost of these intersections, together with A and B, are the vertices of a regular n-gon. Additional regular n-gons have the remaining intersections as vertices. This is illustrated in figure 2, where $n=9$. More generally, if n concurrent lines forming $2n$ equal angles intersect a congruent set of lines the points of intersection are the vertices of n regular n-gons. The case for $n=5$ is illustrated in figure 3. A protractor may be used to prepare carriers for various values of n, or the protractor itself may be regarded as a special kind of carrier.

Figure 4 shows how to draw a polygon similar to a given one. Let an n-gon be given, with vertices marked consecutively

A, B, 1, 2, $\cdots$, $n-2$. Frame the polygon with a carrier, and draw indexes of AB. Draw traces of each side or diagonal that

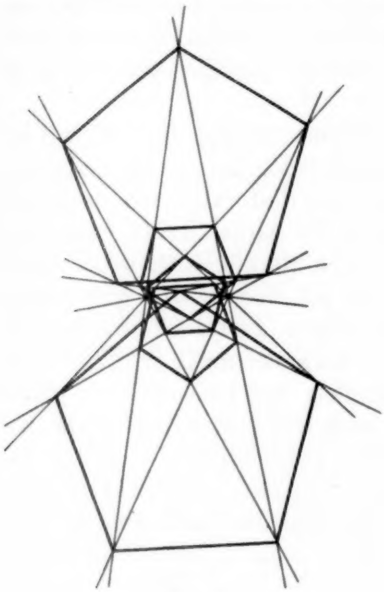

FIG. 3

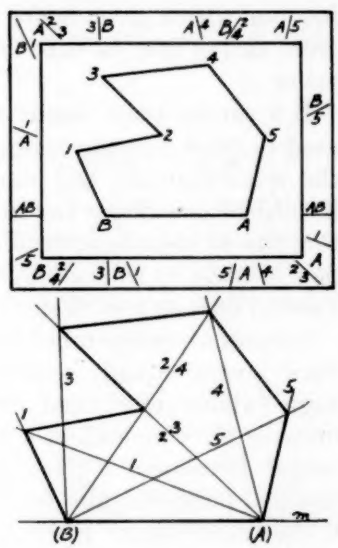

FIG. 4

issues from A (the "A" traces) or from B (the "B" traces). Mark each trace with the letter and number of the vertices through which its line passes. The carrier has now become an instrument by means of which any number of polygons similar to the given one can be obtained. On a work sheet draw a line m. Place the carrier in two different positions so that the indexes

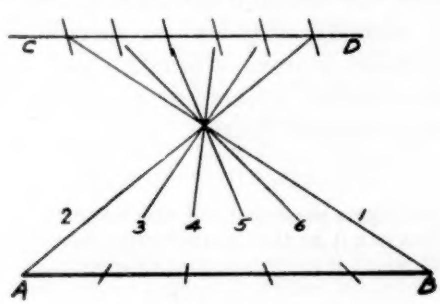

FIG. 5

coincide with m. In one position draw the set of lines determined by "A" traces; in the other draw the "B" set of lines. The two

points on m and the $n-2$ intersections of corresponding lines of the two sets are the vertices of the required polygon.

In each of the foregoing examples a carrier was used in conjunction with a given figure to achieve a specified result. How a given carrier may be used for a variety of purposes is indicated below.

If a carrier bears indexes of two intersecting lines it can be used to draw isosceles triangles, parallelograms, trapezoids, cyclic quadrilaterals, and crossed quadrilaterals such as those formed by inscribing two angles in the same circular segment. One pair of indexes determines several parallel lines if the other pair is made to coincide in various positions with a given line. Parallel lines on a work sheet can, in turn, be traced on a carrier.

Indexes of two parallel lines on a carrier make it possible to draw several equally spaced parallels, the bisector of a given angle (whose vertex need not be accessible), and rhombuses. By drawing the diagonals of a rhombus perpendicular lines are obtained. Division of a given line-segment into a specified number of equal parts can also be accomplished, but with greater ease if the carrier bears traces of several equally spaced parallels. The procedure is shown in figure 5. AB is the given segment. CD, parallel to AB, and the short parallel strokes cutting it are determined by the carrier. The remaining lines are drawn in the order indicated by the numerals. Once a set of equally spaced parallel lines is available (ordinary ruled paper) many figures can be drawn with the ruler alone.

Since perpendicular lines can be drawn indexes of them can be traced on a carrier. A complement of a given angle, right triangles, rectangles, the ends and two other points of a semicircle, and a triangle with its altitudes can then be determined. A carrier that combines indexes of parallels and a perpendicular makes it possible to draw squares, graph charts, equilateral triangles, and other common figures.

At this point an enigma presents itself which in all ages has agitated inquiring minds. How can it be that mathematics, being after all a product of human thought which is independent of experience, is so admirably appropriate to the objects of reality. Is human reason, then, without experience, merely by taking thought, able to fathom the properties of real things? In my opinion the answer to this question is, briefly, this:—As far as the laws of mathematics refer to reality, they are not certain; and as far as they are certain they do not refer to reality.

ALBERT EINSTEIN in *Sidelights on Relativity*

AIRCRAFT INSTRUMENTATION

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(Concluded from February)

B. Present Instrumentation in Commercial Aircraft

Figure 10 shows a typical instrument panel layout in a Douglas DC-3 Mainliner. Most of the instruments are identified on the figure, and have been previously discussed. One unit generally classed as an instrument and not previously mentioned is the automatic pilot. This is shown in the center of the instrument panel.

The automatic or gyro pilot is an instrument that provides complete and automatic control for lateral directional, and longitudinal motions of the airplane. Mounted on the instrument panel, the pilot is provided with a complete picture of the airplane's maneuvers when the auto-pilot is in operation. These same instruments are also suitable for normal flight when the automatic feature is disconnected. It has been likened to the human body, where the gyro units are the "brain," the air relays and oil valves, the "nerve system," and servo cylinders or units, the "muscles."

The complete instrument consists of three separate units to control the airplane directionally, laterally and longitudinally. The units which control the airplane laterally and longitudinally are combined to the extent that they use a common gyro rotor; whereas the unit which controls the airplane directionally is entirely separate. The operation of these three units is identical; the only difference being in the positioning of the gyro equipment with respect to the airplane so that the control is accomplished about the proper axis. For this reason the following general discussion is applicable to all three units.

Each unit consists of a gyro rotor mounted in gimbal rings which allow it to maintain a given position in space regardless of the position of the airplane; a set of air pick-offs which are connected to the airplane and move with it; an air relay connected to the air pick-offs; a balanced oil valve controlled by the air relay; a servo cylinder which furnishes the force to move the control surface; a source of vacuum to turn the gyro rotor and

operate the air relay; and a source of pressure oil to operate the servo cylinder.

A vacuum pump is connected to the case of the gyro instrument and draws air through the two sides of the air relay and through the openings in the air pick-offs. When the airplane is in such a position with respect to the gyro rotor that the pick-off openings are equal and the same amount of air is drawn through the two sides of the air relay, the diaphragm in the air

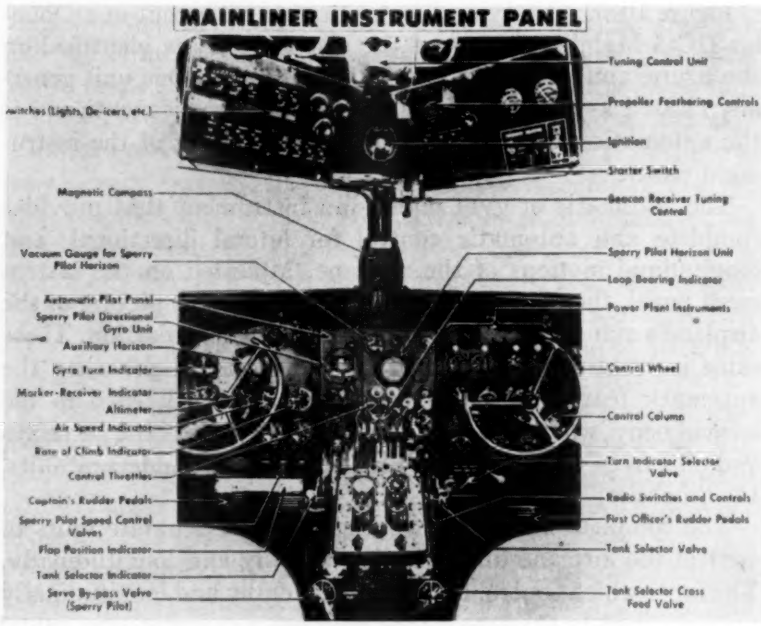

FIG. 10. A panel layout in a Douglas DC-3 Mainliner

relay is centered and the balanced oil valve is in neutral. This position of the oil valve prevents oil from flowing to or from the servo cylinder, and the control surface is locked in place.

If the airplane changes its position, the air pick-offs are moved with respect to the gyro rotor. In this position one pick-off opening is closed and the other opening is full open. Thus no air is drawn from the left-hand side of the air relay diaphragm, and therefore there is no suction on that side. All of the air being drawn from the right-hand side of the diaphragm puts a high suction on that side and moves the balanced oil valve to the right. In this position pressure oil is directed to the left end of

the servo cylinder, and the right end of the cylinder is connected to the return line. The oil pressure forces the piston to the right, operating the control surface in a direction to bring the airplane back to its original position.

If the airplane had moved in the opposite direction, the air pick-offs would have rotated in the opposite direction with respect to the rotor. In this case the air relay diaphragm and the balanced oil valve would move to the left, and pressure would

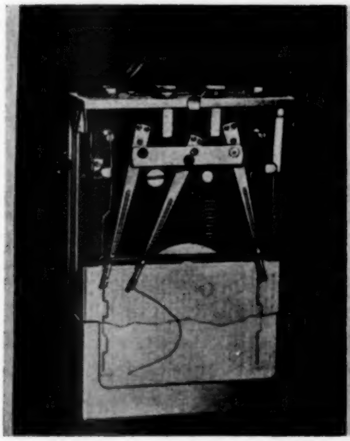

Fig. 11

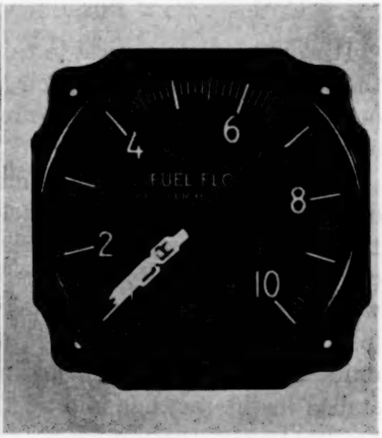

Fig. 12. The fuel flow meter.

be directed to the right-hand side of the cylinder. The control surface would then move up and bring the airplane back to neutral.

One other instrument, used extensively in airline operation, and shown in Fig. 11 is the flight analyzer. This is a unit especially designed to chart the altitude of aircraft during flight in terms of barometric pressure. In addition, two electrically actuated operation pens (mounted to record on the extremes of the chart) show the time during which navigating equipment, such as gyro-pilot or radio, is used. These pens are operated by an electromagnet connected in series with a suitable switch.

Charts are file card size (3×5 inches) and present a complete picture of necessary flight data for operations analysis or for meteorological purposes. The timed chart progresses by gravity as it passes beneath the vertical pens which record laterally across the chart.

There is a very definite need for recorded information in air

transport. The unit has proved useful from the standpoint of being a certification to the pilot that he has flown the trip as planned and/or that he exercised good judgment in the execution of his duties, and giving proof to the Operations Department that the trip was flown as planned. This is particularly useful in answering disputes with other air traffic concerning questions of interference between aircraft relating to their operation at given assigned altitudes.

C. Some New Possibilities in Instrumentation

It would be impractical in this paper to attempt to discuss all the new developments which will be used for future aircraft instrumentation. A few of the more interesting units are worthy of some study, however.

In order to obtain more efficient and accurate power plant operation, the use of torquemeters and fuel flow meters is contemplated in future commercial operation. The latter type of equipment has had considerable use in previous commercial work and in Military aircraft. Fig. 12 shows the fuel flow meter instrument. The complete autosyn equipment consists of two units—a transmitter and an indicator. The transmitter is installed in the fuel line and all the fuel consumed by the engine passes through the metering chamber where the rate is measured and the information transmitted electrically to the instrument on the flight deck.

The measuring element of the transmitter mechanism is a pivoted vane which swings like a gate in the fuel metering chamber, which has a spiral shape. The vane closes the chamber entirely at one extreme position, the distance between the vane and the wall of the chamber becoming increasingly greater, the farther the vane moves from the closed position. Thus, the farther the vane swings from the closed position, the greater the volume of liquid flowing through the measuring chamber. In operation, the gasoline enters the inlet port and is directed against the vane. Impact of the fuel causes the latter to swing, like a gate, in the chamber. The vane moves against the restraining force of a calibrated spring. When these two forces balance each other, the vane stops moving. The final position assumed by the vane represents a measure of the rate at which fuel is passing through the metering chamber. The remainder of the autosyn mechanism transmits motion of the measuring vane to the indicating pointer in the instrument.

An interesting development in flight recording equipment is

the extended flight analyzer of the Friez Company as shown in Fig. 13. The standard recording units include air speed, altitude, vertical acceleration, manifold pressure, and on-off operations records of navigating equipment. It can also record either simultaneously with an autosyn indication, or separately, r.p.m.'s, manifold pressure, fuel pressure, fuel flow, oil temperature, or oil pressure.

Altitude and manifold pressure units incorporate the opposed

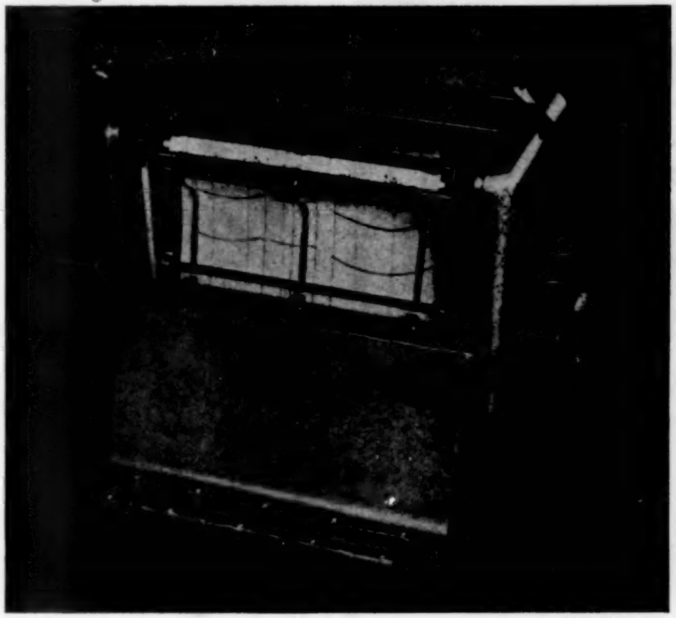

Fig. 13

sylphon system. The air speed unit employs opposed diaphragms, and the necessary pitot and static connections are from the existing lines installed for the separate indicating instruments.

The vertical acceleration unit is a liquid-damped, opposed-sylphon type of special design. A weight is suspended between the vertical sylphons which serve as springs; liquid in the closed system is pumped through a hole in the weight, the size of the hole governing the degree of damping.

Capillary pens each have individual ink reservoirs. The standard chart supply allows approximately 200 hours of recording at a standard speed of 2.4 inches per hour.

Instrument landing equipment offers a means of greatly in-

creasing all weather operation of aircraft and schedule reliability. For this reason it will be in active use in post war commercial transports. While there are several types of instrument landing equipment, only one of these proposed will be described herein.

This equipment consists of three essential elements. First, a means for localizing the airplane over the runway; second, a

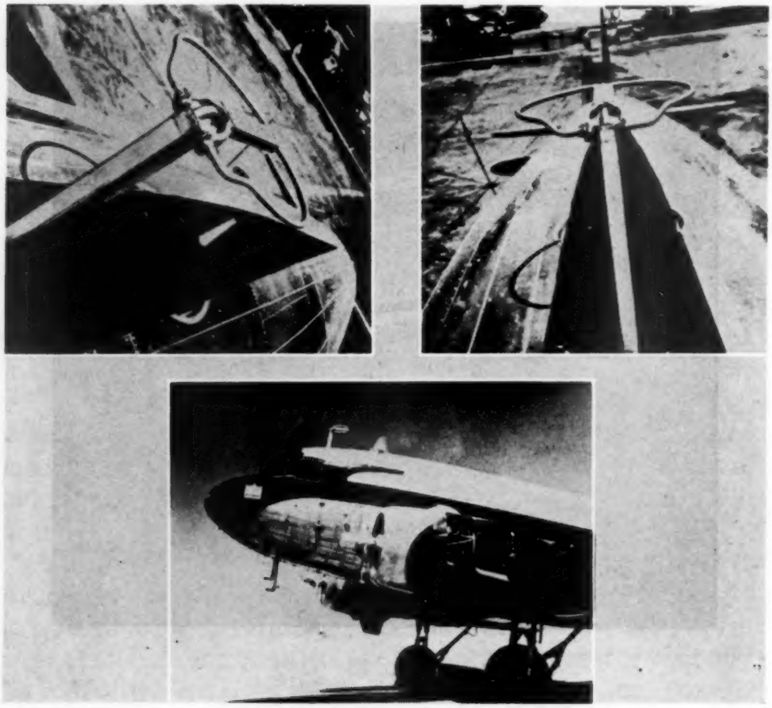

Fig. 14

means for determining the path of the descent; and, third, establishing the position of the airplane along this descent path.

The localizing equipment consists of a high frequency receiver located in the airplane together with a localizer indicator, or instrument and a control box. This is the assembly that provides lateral guidance to, and along the runway when instrument landing is used. In conjunction with the third step a marker beacon unit is necessary in the airplane and three marker beacon

transmitters and a localizer transmitter are located on the ground. The three marker beacon units are spaced at certain predetermined distances leading up to the landing runway. These transmitters operate at a high frequency sending out a fan-shaped vertical beam which automatically lights a light on the pilot's instrument panel as the plane flies through the beam. Each transmitter turns on a different colored light, thus indicat-

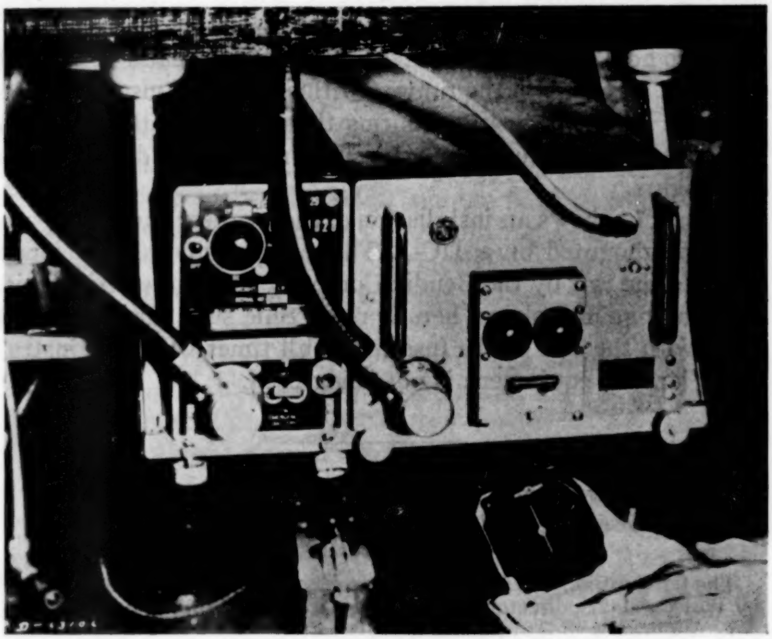

Fig. 15

ing to the pilot exactly where he is. As soon as the aircraft has flown through the beam, the light goes out.

The ground localizer transmitter radiates two patterns; one on each side of the runway. The receiver in the airplane detects one frequency on one side of the runway, and another frequency on the other side of the runway due to a particular system of modulation employed by the transmitter. As the plane flies through these signals the receiver picks them up and transmits them to the instrument in the pilot's compartment, moving the vertical pointer as shown in the instrument in Fig. 15. If the airplane is flying off course, to the right, the needle indicates a full

scale deflection to the right; if flying off course to the left, the needle falls off scale in the corresponding direction.

The localizer signal is actually projected upward at a small angle so that there will exist a constant field strength contour leading down to the runway. The contour thus establishes the glide or descent path, and the receiver measuring this field strength actuates the horizontal pointer. If the airplane goes too high the pointer makes a full scale deflection upward, and if the airplane is too low the pointer goes down. By flying the airplane to hold the proper pointers exactly vertical and horizontal the pilot can land on the runway without outside visual contact and will know his position (during the descent) with respect to distance from the runway by the flashing of three different colored lights.

Figure 14 shows an installation of the localizer and glide path antenna mounted on a DC-3. This equipment was developed prior to the war by the Bendix Company and United Air Lines. The antenna unit shown here is retractible such that it mounts flush with the side of the fuselage at all times when the instrument landing equipment is not being used.

TEN IMPORTANT SCIENCE DEVELOPMENTS OF YEAR 1944 PICKED BY SCIENCE SERVICE DIRECTOR

The ten most important advances in science made during 1944 as picked by Watson Davis, director of Science Service, are:

1. Application of jet-propulsion to aircraft.
2. Use of robot bombs and self-propelled large rockets in warfare.
3. Successful widespread use of the chemical DDT as an insecticide, particularly against the carriers of malaria and typhus.
4. Use of the mold chemical, penicillin, in the successful treatment of a wide variety of diseases.
5. Chemical impregnation of wood that converts soft woods into hard.
6. The use of the silicone family of synthetic resins in waterproofing and insulating various materials.
7. The splitting of human blood seven ways to give albumin for shock, gamma globulin for measles preventive, fibrin foam and plastic for use in surgery, fibrinogen for use with thrombin for cementing skin grafts, globulin for blood typing and red cells for wound healing.
8. Building of a mathematical robot, an automatic sequence control calculator, to speed intricate calculations needed for the war and scientific research.
9. Use of ultraviolet light and triethylene glycol in air to reduce the spread of air-borne diseases.
10. The entry into the war of the world's largest bomber, the B-29 Superfortress.

THE MOTION PICTURE AS AN AID IN GEOGRAPHICAL INSTRUCTION*

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The motion picture brings to geography instruction a very effective aid when it is selected with discrimination and used with a skilled technique. The film brings to pupils facts and ideas that would be otherwise unobtainable. Films can now be made to meet the professional standards of geographical accuracy and suitability for the various learning levels. They should, of course, emphasize man in his natural geographical environment.

The instructor who is to select and use films should be familiar with the various methods of organizing geographical material into film form. Some of these methods are as follows:

1. Collections of raw observational pictures that can be used for laboratory studies.
2. Scientific pictorial surveys of various environments.
3. Geographical pictorial descriptions of man in his natural environment.
4. A narrative or story of man's activity in a selected location.
5. Analytical illustrations in maps, charts and diagrams.
6. Geographical problems so presented in pictorial materials as to aid in their understanding and lead to their solution.
7. Documentary films of unrevised picture records of events.

However, most of the so called documentaries that are available overdramatize some facts and neglect others that are critical.

The above are a few of the methods of organizing geographical material in films. Material of this type when selected with discretion and adjusted to class use has proved its value.

The wise selection of a film subject from the present large number (600) of geographical films and its adjustment to instruction must overcome the bottle-neck caused by the lack of class room standards. This lack of standards has been discouraging to the film producers who would like to know what is wanted. It also discourages those who would like to have a wider use of the better instructional films. Some other factors are present in this bottle-neck, i.e., free films which are used because they are

* An address before the Geography Section of the Central Association of Science and Mathematics Teachers at Chicago, November 24, 1944.

free; the rented film to be shown rapidly and returned quickly; and the high cost of the better films.

Because of these bottle-necks and the wide range in the quality of films, it is essential that each film be evaluated by the teacher before it is used. This is not impossible and it is an aid to the teacher in establishing the correct technique for its use. Teachers of some experience with films soon learn to make a selected film program for the entire semester. A study of these programs shows that on an average one film is used each week in the geography classes. This weekly film serves as a center for the week's discussion.

Geographical films when selected with discrimination and used with appropriate technique are effective aids to thinking. It has been found that the most successful films are those selected for a specific subject and for a learning level based upon the capacity of the pupil.

However, it must be pointed out that because of the ease with which the film communicates ideas, it is quite possible to make a clear presentation of concepts that are ordinarily considered "too difficult" or "too complex." Thus, in the selection of films the error must not be made of underestimating the ability of pupils to comprehend facts pictorially presented, simply because such pupils are slow in reading ability. Ability to learn through pictures is more easily acquired than learning through reading.

Growth in the ability to learn to do geographical thinking and acquire related ideas from pictures seems to follow these steps:

1. The recognition of single objects is the basis for all geographical concepts. Simple, close-ups of animals, people, implements, products and buildings are the beginnings in geography. *Common Wild Animals* and *Farm Animals* are examples of films which give basal concepts.
2. The recognition of activities in their natural setting in a film such as *A Day on The Farm* offers ample opportunities for simple observations and interpretations.
3. Simple activities of man at work can be observed in such films as *The Truck Farmer*, *The Wheat Farmer*, and *The Orange Grower*.
4. A clear recognition of man's adjustment to his physical environment comes with the study of the films, *Fall, Winter, Spring and Summer an on English Farm*.
5. Recognition of the more complex relationships between

man and his environment comes from the film *The Development of Transportation in the United States.*

6. The statement of geographical problems and the presentation of material for their solution from pictorial evidence affords excellent training in the skillful use of the film. *Irrigation in the Southwest* points out the problem of dry land and its reclamation by irrigation.
7. Material concerning the complex relationship between geographical areas may be presented in the film. This is done in the film *Argentina*, which shows the dependence of a great city upon the fertile pampas.

The above ideas about films have been largely concerned with the organization of their content. Let us consider some of the mechanical details that influence the use of films. As to the length of running time of the film, at present 400 feet is standard for class room use. This is from 12 to 14 minutes running time, which fits very well into the regular class period as it gives time for showing and also opportunity for pupil participation in its use. A longer film does not necessarily give better quality and a greater length is not approved for the elementary school. Films in 1,200 or 1,600 lengths are too long for class work and when shown are quite likely to become entertainment rather than material for study. However, it is not wise to set any arbitrary length. A series of 100 foot subjects if closely related might be of great service in building ideas for a unit reel of 400 feet. The 400 foot reel brings ample material for the elementary and junior high school. In the lower levels there is need of considerable experimenting with the 100 foot subjects with selected vocabularies for repeat showings so as to give ample experience in simple recognition.

Regarding the film scene, it should be long enough to give the pupil time for clear recognition of all objects and the action. The continuity and the relationship of the scenes must be long enough to give pupils time to grasp the context and its meaning. No studies have as yet been made concerning the type of material and the length of the scenes necessary to hold the attention at various levels of learning. Likewise, some investigation should be done as to the type of material that will hold the attention of the pupil with a low I.Q. There is need for accurate information as to the picture learning ability of all slow groups. It may be that the solution will be found in short lengths of standard geographical film material to be used for repeat show-

ings. This would give more time for slow learners to develop ideas. It has been found that film pictures help those who find book work almost impossible.

The sound accompanying the pictorial material is most important. Heavy musical fanfare at the beginning of an educational picture is out of place. The commercial practice of filling in the gaps with music is likewise taboo. It is also just good sense to cut out all musical undertones at the introduction, climax, clinches or other places except where it is a distinct part of the scene.

The words spoken by the film should be clear and apt. The voice should be natural and without affectation or peculiarities. The tone should be pleasing and have warmth and interest. The vocabulary should be checked with proper word lists and the words so spaced when spoken as to give pupils time to comprehend their application to the scene. The direct spoken word is more effective than an off-stage comment. The dialogue when used must be clear, natural and pointed. The film *Hop Picking in Kent* has a good dialogue between the native hop pickers and the visitors.

In considering the content of a film it must be more than a series of scenes. Also, it must be more than a continuity of landscape stills. Rather it must present a continuity of action within a natural environment. There must be a close relationship of scenes each with an action which has a distinct and moving center of interest. *Irrigation* presents action and a moving center of interest which is man's effort to grow crops on dry land by supplying water in several different ways. The *New England Fisherman* has an action interest centered in men fishing from New England ports. In *New Earth* interest centers in the problem of reclaiming the land from the sea in the Netherlands. The motion picture becomes a valuable aid when it provides scenes of action which create geographical ideas otherwise unobtainable for most pupils.

In the film use of maps and diagrams, it is necessary that they be so animated that they make clear the relationships of the ideas illustrated. *Expansion of Germany* is an extreme use of maps, while the use of maps in *The Airplane and the World Map* compels definite thinking concerning the globe. All maps must be especially drawn to emphasize the ideas concerned. There should be no broad panning of dim wall maps, hazy globes or the use of indistinct relief maps, as in one of the recent regional films.

Having pointed out some of the advantages of the various types of geographical films, let us give attention to the techniques in their presentation to the class for here is where success is determined. There are many techniques for film presentation. Some aid geographical thinking and others make almost no contribution and are a waste of time and money.

In current classroom practice there are four recognized steps: 1. Conditioning the class to receive the film. 2. The presentation or showing of the film. 3. A review of the material presented, and a discussion and interpretation of the ideas gained. 4. A final checkup, written or oral.

This last step has not been given serious attention, although it is most important and necessary. Some excellent printed test sheets have been prepared but as yet they have not found wide use with geography films.

The mere showing of a film after a few introductory remarks has been quite common. Many teachers however are seeking to make the film a part of class work rather than something novel injected into it. The so-called G.I. method of instruction has stirred some to action but the G.I. method cannot be duplicated in the average school. This method calls for unlimited funds, compulsion in learning, films made for definite training and trained instructors who employ vigorous check-ups.

We can, however, employ much greater discrimination in the selection of material and make a closer adjustment of it to the lesson. We can insist on an organization of geographical materials that formulates definite geographical problems and presents ideas for their solution. Film observations should be so arranged that the pupil will have some basis for the geographical thinking required in the solution of the problem presented. The film *The Corn Farmer* has its sequences definitely arranged to aid the geographical interpretation of where, how and why the Mid-West farmer makes a living raising corn and feeding hogs. This film presents the following closely related scenes: the place, a typical farmer, his immediate environment in buildings, tools, helpers and animals. Along with these are scenes of soil preparation, the rain, the planting, the growth and uses of corn, silo filling and hog feeding. Also calf buying for future feeding, husking corn and its storage until fed to hogs which are finally marketed.

In presenting a film so organized, the common procedure has been outlined in four steps in an above paragraph. This procedure of showing the entire film is often pointless because

of the large number of observations that have to be hurriedly made without enough time to absorb their meaning or grasp their relationship to the problem.

Another method that seems better is to prepare the class to anticipate the various groups of observations. Then, as the film is shown to stop at the critical places for a short discussion of items related to the problem. When all parts of the film have been shown in this manner and discussed, then pupils are ready to combine their findings and reach a final conclusion, the solution of the problem. The check up for such a lesson deals with the facts used in problem solving. Such facts function. They are not merely something to be remembered.

An intermittent showing of a 400 foot film might easily extend over two or three class periods and be a center of considerable geographical thinking.

This method does one thing that is much needed. The teacher must study the film to determine the critical groups of observations and where the film must be stopped. This necessitates thoughtful study of the film and does away with the usual hasty and hurried showing. It also gives time to observe the single items which must be combined for a final solution of the problem.

This seems a better use of the geographical film material for it gives the pupil time for recognition, it provides ideas for interpretation and the opportunity for their application to the whole problem. The running of an entire reel of film without stopping is too common and has brought the geographical film into disrepute. It is the purpose of a film, a text or a picture to bring the pupil material that may serve in geographical thinking. The intermittent showing provides opportunity to discuss and use the various observations at the time they are made.

If it is true that what a pupil gets out of any subject is simply the images he himself forms, then it is clear that there is danger in presenting too much, too fast. It is not reasonable to expect pupils to form valuable images when scenes are rapidly presented by the hundred. Recognition is the basis of geographical thinking and necessary time pauses for its operation must be given when using these swiftly moving scenes.

It is most essential to break up the innocuous passivity of pupils that prevails when a reel of film is shown continuously with no opportunity for pupil participation. No teacher would exhibit a hundred or more still pictures without giving pupils

ample opportunity to assimilate their observations. So it would seem that the intermittent showing of certain selected films would give pupils some chance to obtain ideas and form images that they can use. Geographical films provide materials for geographical thinking. The teacher must present the film so pupils can gain the understandings essential for geographic thinking and use them in such thinking.

INDUCED CURRENT DEMONSTRATION

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The assembly here shown is designed to save time in induced current demonstration and also to show some points in a manner more satisfactory than heretofore we were able to do.

The demonstration galvanometer we have is not sensitive enough to show noticeable deflection with a single wire and the laboratory galvanometers are too small.

A satisfactory semblance of the single wire was obtained by winding 20 turns of No. 32 wire in a coil, *L*, one foot in diameter, with lamp cord leads soldered to the ends. The coil was then wound with adhesive tape except for a section about three inches long, from the ends of which the lamp cords project. This gives the appearance of a single large wire.

With the ends connected to the large galvanometer, a fairly large deflection is shown when one end of a strong bar magnet is moved across one side of the loop. The white taped coil so closely resembles a single strand that classes consider it as such, and with the coil, a voltage is built up strong enough to give a satisfactory deflection which a single wire would not do.

To show how this induced current increases with a stronger field, a U shaped electromagnet, *E*, was wound with many turns of No. 28 enameled wire. To the inner side of each pole is attached a thick piece of soft iron, leaving a space of only about one-eighth of an inch between poles through which the wire will barely pass.

The electromagnet is connected through switch *A* and two lamps or heater units, serving as a low resistance, to the direct current source permitting the use of a real strong current.

Throwing switch *A* to the left turns the current on to the

removable primary, *P*, of an induction coil whose secondary, *S*, may be connected to the galvanometer by throwing switch *B* to the right. It is then ready for demonstrating the inserting or withdrawing of the primary or breaking the circuit of the primary, or else the permanent magnet may be used.

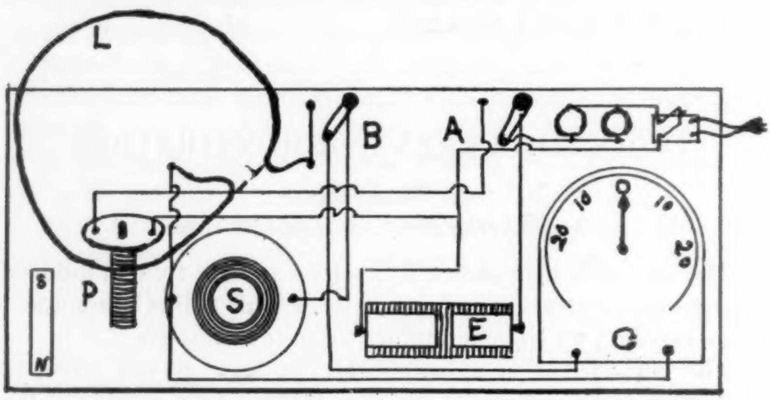

FIG. 1

Since these are all kept together on a single board the whole thing is ready in a minute's time. Being a somewhat simple demonstration one might otherwise hesitate to take class time to get out and connect the separate units.

The mounting is on an eight inch board.

NEW WOOD PRODUCTS LABORATORY IN WASHINGTON

A new laboratory for improved physical and chemical utilization of wood and its products was officially opened in Washington Jan. 9. The Teco-Shop Laboratory of the Timber Engineering Company is appropriately located in the middle of a wooded area on the outskirts of this city.

The laboratory is composed of two divisions. Dr. Eduard Farber is in charge of the chemical division, which has already made advances in the study of the utilization of lignin, partner of cellulose in wood, but all too frequently regarded as a waste product. J. L. Stearns heads the physical department where soft grades of wood are made hard under impregnation. Gaily hued pieces of wood have been colored not just on the surface, but throughout, by this process. The wood products development shop and wood chemistry laboratory are expected to provide an additional link between basic research organizations such as the U. S. Forest Products Laboratory and practical application of this research.

THE CHEMISTRY PROGRAM AT EAST TECHNICAL HIGH SCHOOL

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Cleveland's oldest technical high school, now known as East Tech, opened October 1, 1908. It was for a number of years coeducational but became an all-boys school in 1930.

Elementary chemistry has been given during the second or sophomore year of the school ever since it opened. The first graduate to be listed as having completed a course in industrial chemistry received his diploma in 1910. No records remain of the exact nature of the course during its first years, but it is known that the work was largely analytical and that the numbers of students increased rapidly.

The divisions of the present course in industrial chemistry, as developed by the writer, have remained essentially the same since 1918, although the subject matter and experiments used have undergone many changes.

General Discussion

Technical high schools were one of the first steps in the modern educational trend of fitting instruction to the needs of students instead of forcing them all through the same groove irrespective of their individual talents or interests.

In the past we forced college entrance education upon a vast number of boys and girls who had no possible chance of going to college. The tragedy of all this was that the accident of birth limited the ones who could go to college to the children of the more affluent parents, although these children were not always the ones best fitted to profit by college training. One must admit that the children of poor parents are sometimes more talented, more keen and eager to learn, and often more industrious than many who are able to attend college.

To understand the problem of the technical high school, one must also know more about the type of student attending it. We draw our quota of the best and the poorest students, but between these two groups is a much larger one of only average intelligence rating.

This "average" technical student is rather an unusual animal, of a different species from that found in the academic high schools. He used to drop out of school at about the eighth or

ninth year, because he had no capacity for assimilating history dates, and was irked beyond endurance by being forced to analyze sentences from *The Ancient Mariner* when he longed to be analyzing steel or running a lathe. Because of his indifference to orthodox school work he was too often set down as dull, lazy, and a troublemaker. Now he can not merely drop out. He is kept in school by law, and something must be done about him. The modern Junior High School tries to help. There he does find some things he really enjoys. He enters the technical high school, then, with high hopes but a considerable inferiority complex. The change that comes over such a boy when he finds that here he is learning what he most wants to learn is often astonishing. Witnessing this transformation is one of the rewards of teaching.

In general, then, the purpose of the technical high school is to educate by building upon the student's own interests and abilities. Supplying industry with trained workers is of secondary importance. Most of our boys come from the poorer families and are keenly aware of their need to learn something they can actually use in making a living.

The printed outline shows that each student in the course at East Tech puts in a half-day every day for two years on his own technical subject, the other half-day being devoted to the regular high school academic subjects. It is this generous allotment of time that makes the technical course possible, enabling younger students to master some of the fundamentals of their chosen work.

The sketchy details given in the outline suggest the subject matter of the classroom and laboratory work in each division of the course sufficiently well. Three rather special phases of the work, however, which have been added to the course as the result of a system of interviewing hundreds of students, may be of enough interest to warrant further description. This investigation into student needs has been largely responsible for getting boys of different learning rates started with a fairly even chance for their success.

New Answers to Old Problems

As to the three phases that are handled in a special way at East Tech, it should be remembered that the usual high school chemistry course begins with theories, laws, atoms, molecules, gases, etc.—all invisible and abstract—and ends with rather uninteresting lists of properties of metals and their compounds.

Arithmetic as applied to chemistry is another struggle for the young mind. Then, too, in general chemistry, the boy is given small chance for creative and imaginative work. To meet these three problems, (1) an "Arithmetic Review," (2) an "Introduction to Chemistry via the Metals," and (3) a series of "Special Projects," were added to the course.

The Arithmetic Review

Nearly all students interviewed readily admitted that their greatest difficulty in elementary chemistry was the lack of a good foundation in arithmetic. They could not add, subtract, multiply, or divide with any assurance of correct results. Most of them had no knowledge whatever of ratio, proportion or per cent. The slower students were terrified at the prospect of combining proportions, and thrown into a panic at the whole idea of atomic weights and calculations from formulae and equations.

To meet this situation we took over into our course from the mathematics department the class to which our first year students were then assigned, a class in shop mathematics with no relation whatever to chemistry. A special course in the fundamentals of arithmetic and their applications to chemistry was prepared. Simplified ways of presenting addition, subtraction, multiplication and division, and methods of checking calculations for accuracy were sought and gathered into a mimeographed outline of study. In this text, prepared by the writer, these elementary processes were worked out graphically and described in the simplest language possible, so that the poor bewildered boy who is ashamed to ask for help, and fears being scolded for his ignorance, can find from his book whenever necessary just how to add, multiply and divide, find per cents and solve proportions or carry on any of the operations he has forgotten or never knew. Under this plan, the boy is relieved of the burden of being taught how to think with every other sentence, and his natural questions are not answered by riddles, rather he is presented with a tool and taught how to use it. Learning how to "figger" in this free fashion proves a real revelation and thrill for many a boy and takes away his fear of calculations. Calling it *Chemical mathematics* also makes it easier to take. At least the boys can no longer maintain the old alibi that they were never taught arithmetic.

As the better students often do not need so much drill in these fundamentals, special methods and devices for short cuts

and quick calculations are provided for them, such as adding from the left and other ways of dealing with division, rapid checks, and drills in significant figures. Following this review of arithmetic, the problems usually met in general chemistry are presented. Such students as are unable to learn arithmetic or reason in mathematical ways are eliminated from the course.

The first term of chemical arithmetic proved so successful in rescuing floundering students that we have added a second term in which the problems of analytical chemistry and the use of logarithms and the slide rule are presented.

Introduction to Chemistry via the Metals

Interviews with students brought out the fact that general chemistry, as ordinarily taught, reached a climax of interest, with the faster and more imaginative students, by the end of the first half year; everything after that (usually the chemistry of metals) was so dull that many of them came to hate the subject. With the slow students, on the other hand, the first term was a nightmare of difficulties while the second term was more intelligible.

To meet this problem, it was decided to try a plan that was first suggested by the writer about 1910, put in operation in 1919, and used as opportunity offered since that date (vide School Science and Mathematics, Vol. XX, Jan., 1920.) The plan is essentially to reverse the usual order and begin the study of chemistry with the metals, approaching the subject from the physical rather than the chemical side, beginning with such physical and chemical properties by using methods borrowed from metallography, microchemistry, crystallography, mineralogy and testing materials. Under this plan, both the slow and faster students seem equally interested, and the slower ones are given a chance to shake off inferiority complexes by finding something they can do and understand.

Such metals as are readily melted are cast into bars. The students saw these bars and those of other metals and are taught how to shape, polish, and etch the sections. The pieces are carefully measured and weighed for the determination of density. This permits the use of metric weights and measures and makes density a matter of personal observation. Some of the students make a project of shaping the metal pieces to an exact cubic centimeter, from which a set of density specimens of different metals is being accumulated. In addition to the metallic elements,

specimens of wrought iron, steel, cast iron, brass and other alloys showing distinctive components are prepared and studied. Many of the specimens are previously heat-treated to enlarge the grain size so that the crystalline structure may be seen.

Polishing the specimens is done by hand at first, with the idea that the student will come to know the properties from his own observations, and each metal will mean more to him than just a strange name.

Etching brings the first evidence of chemical action, and this is made the basis for beginning the study of chemical reactions and compounds. Following the progress of etching with the microscope is a thrilling revelation to most boys. What seemed to be just a chunk of metal is now seen to have a delicate pattern of crystal grains and to contain various parts.

Ordinary etching is followed by deep etching, after which the specimen is examined for fibrous structure or etch figures. The deep-etch solutions are saved and, by evaporation, a crop of crystals is obtained. Some of these are dried and kept in small specimen bottles which the student has labeled with the formula. Thus chemical nomenclature is not just a meaningless fitting together of strange names, but is rather the finding of a natural, inevitable name for something the student has just made.

The growing and observation of these crystals lead naturally to a general study of crystal forms and properties. Crystal models are used at first for the measurement of angles, then large natural crystals from the mineralogy collection are studied and measured, thus introducing many questions as to the formation of crystals—questions which aid in developing the study of chemical reactions. Some of the crystals the student has made are redissolved and the metal "brought back" by electrolysis or chemical displacement. Sometimes this reproduced metal is again redissolved and the compound recrystallized several times to build up faith in chemical changes—a faith that has proved sadly lacking in many young minds. For this purpose copper is the ideal metal to start with, because the whole cycle can be so quickly completed and the copper brought back with the whisk of a knife blade.

The crystal solutions are also used for some microchemical and spot tests. Seeing crystals grow out from the edges of a spot on the slide while watching them through the microscope is another revealing experience which lends animation to the otherwise dull subject of the metals.

While these crystals are being made, their properties and those of the metals and their other compounds are being studied from the text-book in the classroom. The crystals are also used to make such materials as pigments, inks, blue-print paper, etc.

In this preliminary work with the metals, little mention is made at first of atoms and molecules, but symbols are used, and the students know most of the common acid formulae. From this, the beginnings of equation writing are easily started, which leads to accounting for the elements not contained in the crystal. The questions of how much of the metal has been removed in the etching, and how much of the acid has been used up lead naturally to the question of combining proportions. Some experiments in the direct union of powdered metals with sulphur are always helpful, and in this way some of the more difficult ideas are launched without confusing the slower students.

After about six weeks of the metal work, during which crystal compounds of eight or ten metals have been prepared, attention is called to the matter of identifying the metals as elements and in compounds. Some special tests for the metals, borrowed from mineralogy and blowpipe analysis, are used at first; then tests from solutions. From these simple operations the study of qualitative analysis is launched and the classroom study is devoted to the reactions of the elements and their compounds as they come in the analytical groups. The scheme of analysis is abbreviated at first so that the students may not be lost in the maze of separations, and may more quickly comprehend the system as a whole. Students are encouraged to devise methods of their own for separating certain metals.

The advantage of this method of approach to chemistry seems clear. An ordinarily dull and tedious term's work is converted into an interesting method which equalizes difficulties for students of various capacities and learning rates. Slower students lose their fears while more imaginative students do not lose interest.

By the second term, both groups now approach the study of gases, gas laws, combining and atomic weights, ionization and the more intricate phases of general chemistry, with more confidence, and the year's work rises to a climax of interest instead of falling away to an anti-climax with the metals coming last.

Special Projects

All students like to work on individual projects. These may be

of the student's choosing, some job brought in from outside the school, or an assignment that has grown out of their studies. The ample time allotment for the course makes it possible to assign projects at any time during the two years but especially in the last term. We encourage analyzing and testing materials for outside parties, and similar jobs for other departments in the school. These jobs are assigned to students who have shown skill and interest in the particular work required.

At any time during the course, if a student gets an idea, we try to give him a chance to work it out. Certain projects that have been carried out at various times may be mentioned:

Many students have built their own balances and made sets of weights. Some have purchased microscopes with which they carry on microchemical projects of their own. Many have interested their fathers in building polishing equipment at home, to continue the study of metals there. A home-made goniometer was another project.

Much of the first equipment used in the course was designed and made by the boys in the school shops. A student-made polishing machine and camera are still in use. A class micro-projector, designed and built by a student about five years before the Euscope was put on the market is also still in use.

At three different times, analytical and testing work has been carried on by contract with outside firms. Another commercial project which was reported in the *News Edition* of the *Journal of Industrial and Engineering Chemistry* for February 20, 1923, was the manufacture and marketing of a spot remover.

The thermite reaction as a special project has evidently turned a number of our students into the field of metallurgy. Making models of chemical engineering machinery is a favorite project with boys of a mechanical turn of mind. A collection of crystal specimens and organic preparations made in the laboratory is exhibited every year.

One of the most original projects was an "Electromagnetic Balance" in which, to quote from the boy's report,—"An air-core electro-magnet is placed under the weight-pan of an analytical balance. The strength of the magnet is varied by means of suitable resistances which cut current from the circuit until the weight of the object is just enough to pull the weight-pan from the magnet. The weight of the object is then read from a vernier dial attached to the resistance." This method worked very well for smaller weights.

War Changes

The war emergency has caused a few changes from the program as just outlined but we hope to be back on the full schedule very soon.

Strangely enough the chemical mathematics which the boys need very much these days was taken out of our hands for the duration and the course was divided into two sections of one year each with the idea that a boy might broaden his training by taking some other technical course or more academic subjects for half the time, or he might shorten his course to be able to graduate before induction. Most of our students, however, continue for the full two years.

Our program was well adapted for this change. The first year was designated as metallurgical chemistry and more stress than ever given to the examination and testing of the metals, themselves. The second year is now called industrial chemistry and still consists of one term of organic chemistry with about forty preparations made in the laboratory.

The second term has a study of chemical industries for the class room and volumetric analysis in the laboratory. Another special change caused by the war has been the introduction of a series of lectures on war materials—explosives, gases and metals in the study of chemical industries.

Other War Problems

Because of the war, or coming along with it, we are confronted with the fact that laboratory work in the industries is coming to be handled to such an extent by instruments. So many of our students work summers and part time in plant laboratories that it is difficult to keep them interested in gravimetric and ordinary procedures when their minds are full of wave lengths, etc. And yet the industrial people want our boys to be trained in these fundamentals.

A high school certainly can not afford to keep step by purchasing expensive, spectrographs, photelometers, electro titrators, photoelectric spectrophotometers, polarographs, electronic photometers and electron microscopes as fast as they are being placed on the market.

Our only suggestion for this situation is to get a few of these instruments to prevent the impression that we are entirely out of date and try to hold the interest in this way.

With that in view we were fortunate in securing an X-Ray outfit discarded by a laboratory installing a more powerful outfit and we are just getting ready to put it in operation. It will be used in connection with the school's metal departments such as aeronautics, foundry, machine shop and welding.

A movie in color showing some of the work of the chemistry department at East Tech High School concludes this description of our program.

CHEMISTRY PROGRAM

EAST TECHNICAL HIGH SCHOOL, CLEVELAND, OHIO

ELEMENTARY CHEMISTRY—ONE YEAR

YR. & PERIODS	CLASS ROOM
10TH YEAR FIRST HALF 4 45-Minute Periods Weekly	Text—*Dynamic Chemistry.* Gaseous Elements—O, H, N, Cl. Valence, Formulae, Equations, Atomic and Mol. Wts. Percentage Composition. Visual Aids, Films, Pictures, Lab. Demonstration of Fundamental Principles of Chemistry, One Period Weekly.
	LABORATORY
10TH YEAR FIRST HALF 2 45-Minute Periods Weekly	Text—*Laboratory Manual for Dynamic Chemistry.* Physical and Chemical Properties of Elements and Compounds and their Chemical Reactions. Colloids, Metals.
10TH YEAR SECOND HALF 4 45-Minute Periods Weekly	Text—*Dynamic Chemistry.* Metals and Their Compounds, as to Properties and Uses. Weight Problems Based on Metals. Metal Industries. Organic Compounds. Foods. Medicines, Petroleum.
10TH YEAR SECOND HALF 2 45-Minute Periods Weekly	Text—*Laboratory Manual for Dynamic Chemistry.* Uses of Metallic Compounds—Paints, Water-softening. Tests for Ions. Visual Aids on Metallurgy, Study of Methods of Heat Treatment and Testing of Metals. Food Tests, Dyes.

INDUSTRIAL AND METALLURGICAL CHEMISTRY—TWO YEARS

	CLASS ROOM
11TH YEAR	CHEMISTRY OF METALS
FIRST HALF 1 45-Minute Period Daily	Text—*Smith's College Chemistry and Reference Texts.* Elementary Principles of Metallurgy and Metallography, Properties of Metals and Their Compounds. Principles of Solution, Precipitation, Separation and Identification, Calculations.
	LABORATORY
11TH YEAR	MEASUREMENT OF METALS
FIRST HALF 3 45-Minute Periods Daily	Metric Dimension, Volume, Weight, Density, Strength and Hardness. Metal Work and Etching. Physical Testing: Melting and Casting. Elementary Metallography. Growth of Crystals from Etching Solutions, Wire Drawing, Heat Treatment, Micro-

chemical Tests, Chemical Precipitation, Electromotive Series, Spectroscopy.
Abbreviated Scheme of Qualitative Analysis Based on Brockman's Method. 35 Unknowns, Crystals. Salt Solutions, Minerals, Alloys and Household Materials. Purity of Reagents.

11TH YEAR — CHEMICAL MATHEMATICS

FIRST HALF
1 45-Minute
Period Daily

Arithmetic Review—Addition, Subtraction, Multiplication, Division, Fractions, Decimals, Ratio, Per cent, Proportion and Mensuration. Derivation of Formulae, Percentage Composition and Equivalent Weight. Calculations from Equations, Gas Volumes, Density of Solids, Liquids and Gases. Text—*Pierce.*
No laboratory work with Chemical Mathematics.

11TH YEAR — GENERAL CHEMISTRY

SECOND HALF
1 45-Minute
Period Daily

Text—*Smith's College Chemistry*—First Half. Fundamental Laws, Combining Proportions, Gas Laws, Equilibrium, Ionization, Atomic Structure, Periodic Classification, Theories. Calculations of Analytical Chem. References—*Farnsworth, Engelder, Mahin, Pierce & Haenisch, Willard, Hamilton & Simpson,* and others.

11TH YEAR — GRAVIMETRIC ANALYSIS

SECOND HALF
3 45-Minute
Periods Daily

Study of Analytical Balance and Methods of Weighing. Study and Practice of Analytical Processes—Sampling, Dissolving, Precipitation, Filtering, Washing, Ignition, Calculations and Records. Determination of Individual Constituents: H_2O, Fe_2O_3, Al_2O_3, CaO, MgO, SiO_2, SO_3, CO_2 and Metals.
Complete Analysis: Limestone, Portland Cement, Slag, Alloys. Physical Testing of Cement. Electroanalysis.
Text—*Pierce.* References—*Lundell, Hall, Scott,* and *Griffin.*

11TH YEAR — CHEMICAL MATHEMATICS

SECOND HALF
1 45-Minute
Period Daily

Text—*Engelder.* Calculations of Volumetric Analysis, Concentration, Acidimetry, Oxidations and Precipitation. Calculations of Gravimetric Analysis, Stoichiometry, Equilibria, Ionization, Solubility Products.
No laboratory work with Chemical Mathematics.

12TH YEAR — ELEMENTARY ORGANIC CHEMISTRY

FIRST HALF
1 45-Minute
Period Daily

Text—*Conant.* Homology, Nomenclature, Typical Aliphatic and Aromatic Compounds, Reactions and Practical Applications.

12TH YEAR — ELEMENTARY ORGANIC PREPARATIONS

FIRST HALF
3 45-Minute
Periods Daily

Text—*Adams & Johnson Laboratory Methods.* Preparation and Reactions of 35 Organic Compounds. Distillation, Extraction, and Purification. Analysis of Gasoline, Lubricating and Fuel Oils.

12TH YEAR SECOND HALF 1 45-Minute Period Daily	INDUSTRIAL CHEMISTRY Lectures and Library Work. References—*Read, Riegel, Rogers, Badger, Benson, Walker, Thorpe*, etc. Manufacturing Processes and Materials. Portland Cement, Iron and Steel, Paints, Rubber, Sugar, Rayon, Plastics, Explosives. Designing and Model-Making. Trips to Chemical Industries. Cost Data and Calculations.
12TH YEAR SECOND HALF 3 45-Minute Periods Daily	VOLUMETRIC ANALYSIS Text—*Pierce*. Calibration of Apparatus. Preparation and Standardization of Solutions. Acidimetry: Limestone, Soda Ash, etc. Oxidation: Fe, Ca, S, and Cu. Precipitation of H_2SO_4, Ag and Cl. Electrometric and Gas Analysis, Colorimetry and pH Determinations.
12TH YEAR	INDUSTRIAL PROJECTS Production, Analysis and Investigation.

THERMAL CLOTH DEVELOPED TO LINE AVIATORS' SUITS AND FOR EVACUATION BLANKETS FOR WOUNDED

Warm, soft thermal cloth has been developed to line aviators' suits and for evacuation blankets for the wounded. Hundreds of pile tufts are woven on each side of the cotton warp, making the fabric exceedingly warm despite its light weight. The tufts tend to trap the warm air from the body and keep it from escaping.

The cloth was designed to replace sheep's wool in the jackets of aviators' flying suits since it does not harden in high altitudes as does the natural product. When used as a lining inside an outer shell of tightly-woven windproof fabric, it makes one of the warmest and most comfortable of flying garments.

To seal upholstery against the infiltration of dirt and to anchor more firmly the cotton warp and filling threads, fabric used to cover the seats of modern streamlined trains is coated with a latex compound. A coating process has been developed which permits air to pass through the fabric despite the coating: this makes the seat cooler and more comfortable.

Specimens of automobile upholstery, through which you can blow smoke even though the back has a rubber coating; of thermal cloth with the soft pile on both sides; and of upholstery for airplanes where light weight as well as durability is important, are only a few of the samples of upholstery fabrics.

A NEW CATALOG

A new catalog of technical books has just been issued by The Chemical Publishing Co., Inc., 26 Court Street, Brooklyn 2, N. Y. This catalog includes the latest books on chemistry, technology, physics, general science, mathematics, engineering, foods, formularies, drugs and cosmetics, gardening, medicine, metals, technical dictionaries, etc.

This catalog, conforming with the requests of technical and scientific workers and librarians, gives the date of publication of each book as well as price, number of pages, detailed descriptions and full table of contents.

A copy of this catalog will be sent free to everyone who is interested in keeping up with the latest technical and scientific progress.

SOME NOTES ON BEHAVIOR

Part One*

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The layman usually thinks of the problem of behavior as a study in mental processes or of the mind. The term mind is difficult to define except in very abstract terms, and whether or not animals, including man, have what we call mind, is a matter of inference. The word behavior, in a general sense, is a comprehensive term referring to any response which an organism may make to an internal or external stimulus. However, for the purpose of our present discussion we can limit the meaning to include only the overt responses so elicited.

The prime factors influencing the quality of the behavior responses of organisms to any given stimulus are (a) *the structural organization*, and (b) *the physiological state* at the time the response is made. The former determines not only the kind of stimuli which the organism is capable of perceiving by virtue of its sensory endowment, such as the possession of specialized receptors like eyes and ears, or more generalized ones as chemoreceptors, photo-receptors, and touch and pressure receptors, but also the nature of the response that can be made as a result of the correlative powers of the nervous system, if present, and the possession of a distinctive locomotor mechanism. For example, organisms such as plants or the lower animals lacking image-perceiving eyes possessed of color vision, a highly developed correlative system (brain), and efficient locomotor appendages (limbs), do not respond, in fact, cannot respond to any given stimulus in the same manner as do organisms so endowed. The beauty of an ocean sunset, the joy of running on an open beach, the smile of Mona Lisa, are inevitably non-existent for them.

The importance of the physiological state of an organism in determining the character of the response given to a stimulus cannot be over-emphasized. An organism that has just eaten is in a different physiological state from a hungry one and therefore reacts differently to the presence of food than does a starving individual. An animal in the breeding season behaves differently toward members of the opposite sex from the way it did a month previously, and so on.

* Part Two and Part Three will appear in later issues of this Journal.

Broadly speaking, we can classify all behavior as either learned or unlearned. The essential distinction between learned and unlearned behavior is made on the basis of whether or not behavior is modified through experience. However, this modification of behavior through experience (that is, true learning), must be acquired rapidly enough so as not to be the result of structural modification and permanent enough so as not to be the result of a temporary physiological state.

We are now in a position to examine the types of behavior as exhibited by the two great kingdoms of organisms: first, the plants, because here behavior is found in its simplest, most mechanistic form; and later, the animals among whom we shall encounter an ever increasing complexity and diversity of behavior as we pass from the lower to the higher forms.

Plant Behavior

Behavior in plants is of the unlearned type. They do not profit by experience. Their behavioral reactions to a given stimulus for a given physiological state are invariably the same. The behavior reactions of plants are indeed not dissimilar to those of many animals; the fundamental difference is precisely a difference of rate. Take a particular case: The growing root of a nasturtium seedling is photographed every fifteen minutes. The resulting film is run through the projector at the ordinary rate of fifteen pictures a second. The rate of movement has thus been magified 13,500 times, and the behavior of the root tip now seems that of an animal instead of a plant. It pushes its way like a white worm through the soil; like a worm's head, its advancing end weaves from side to side as it moves onwards; like a worm it avoids obstacles by bending and crawling around them. The plant, rooted in the soil cannot escape danger by flight, or capture food by active pursuit; rapid reactions are, with rare exceptions, pointless, and its movements are almost wholly devoted to attaining the most favorable position for itself and its organs, and are thus *unrelated* to enemies or to prey or to any rapidly moving object whatever. This being so, adequate behavior responses can be executed quite well through the slow agency of growth, and no special rapid machinery such as nerve and muscle has ever been evolved. The basic mechanism for these growth movements is probably chemical, growth hormones. Occasionally a more rapid type of response is present,

namely turgor movements caused by changes of the diffusion pressure in the cells of specialized structures.

Growth Movements. Probably the most general reactions of plants are growth movements. All parts of a plant do not react in the same way to a particular environmental stimulus. For example, the main roots of plants grow in the direction of the pull of gravity, while stems grow in the opposite direction of the pull of gravity. Roots are, therefore, said to be positively geotropic and stems negatively geotropic. Experiments demonstrate that the mechanism of response for young roots is located at the very tip. If only one millimeter of a root tip is cut off the root is unable to respond. The actual response, however, occurs in the four or five millimeters back of the tip. The root tip cells are young, soft, and embryonic. They show no specialized mechanism of response, but the sensitive part responds not only to gravity but also to water and chemicals in the soil.

The subject of growth movements may be further amplified by recalling the familiar fact that leaves respond to light. It is impossible to grow a radially symmetrical plant by exposing only one side to the light as, for example, a potted geranium placed in a window of a home. The leaves of such a plant turn toward the light. The top surface of the blade faces the window, and what is usually the under surface of the blade faces the inside of the room. The branches grow out laterally making a plant that is widened from side to side instead of the usual radial symmetry shown by plants grown out-of-doors.

Growth movements which involve changes in the direction of plant parts are caused by a differential growth rate. The cells on one side of a root, stem, or leaf petiole, elongate more rapidly than those on the other, thereby changing the direction of growth.

Growth Hormones. Pursuing the "why" of this response still further, recent investigation shows that the differential growth rate is due to growth hormones whose distribution is governed in part by light. The hormones become more concentrated on the shaded portions of the stem and thus causing the cells on that side to elongate faster and to a greater degree. When stems are placed in a horizontal position, gravity seems to govern the distribution of the growth hormones. More of them collect on the underside of the stem. The increased elongation of the cells on that side causes the stem tip to bend upward. Odd as it may

seem, in roots these hormones appear to decrease the rate of growth. Their accumulation on the underside of a root placed in a horizontal position causes the root to bend downward. It is evident from the preceding discussion that a chemical mechanism is responsible, at least in part, for the reactions of plants.

Turgor Movements. Plants respond also by turgor movements. These movements are due to quick changes in the osmotic pressure in certain sensitive cells. High osmotic pressure inflates the cells and makes them turgid; low osmotic pressure deflates the cells and makes them flaccid. Only certain plant cells respond to such rapid changes, and many plants are without these sensitive cells. When present they are usually located in an enlarged structure at the base of the petiole and in the stalks supporting the leaflets. These sensitive cells are all similar, spherical in shape, and with comparatively thin cell walls. When distended by high osmotic pressure they hold the leaves spread out more or less horizontally. A decrease in osmotic pressure causes the leaves to droop. In the sensitive plant the drooping may occur almost instantaneously. The stimulus of touch or high temperature applied to the tip of a leaflet produces an effect on cells far away from where the stimulus was applied. Water instantly passes out of these cells; they become soft and flaccid, and the leaves droop just as quickly. If they are left undisturbed for a time, water moves back into the cells, and the leaves gradually assume their expanded position.

In other plants turgor movements are brought about by changes in light intensity. The cells on one side of sensitive structures are inflated and turgid, while those on the other are deflated and flaccid. In intense sunlight the leaves of some plants will assume a partially edgewise position; in light of lesser intensity they assume a position more nearly perpendicular to the sun's rays. The so-called sleep movements of clover are governed by light intensity. The leaflets are held expanded in the sunlight but at night they droop. These movements are caused by changes in the osmotic pressure of the sensitive cells.

In the case of Venus' fly trap the action is also brought about by changes in turgor. An insect comes in contact with certain sensitive hairs. An impulse from them is transmitted to sensitive cells that form the hinge of the leaf. The changes in osmotic pressure in these hinge cells cause the leaf to close and entrap the insect.

Animal Behavior

While plants specialized in *directional growth*, animals took another course and developed an apparatus for *directional movement*, with the more specialized sensory, correlative, and motor mechanisms that this faster method of response requires. But irrespective of these advances animals may be ruled in their activities by external stimuli as tyranically as plants. In general, the lower animals do not have any great capacity for profiting by experience. Their responses, like those of plants, are primarily of the unlearned type. The mammals with man at their head, and the insects with ants, bees, and termites as their highest specialization are the culminating branches of two divergent stocks: the Vertebrates, and the Arthropods. In mammals we note the greatest ability to profit by previous experience, that is, to learn; on the other hand, the acme of instinctive behavior is exhibited by the insects.

Unlearned Behavior. Usually, three classes of behavior are considered as being of the unlearned type, although as we shall see in a moment, they are not separate entities, each independent of the next, but are built up one upon the other into a unified reaction pattern. They are *reflex behavior*, *tactic behavior*, and *instinctive behavior*. The morphological basis of all three forms of unlearned behavior is presumably the reflex arc.* The difference between these types of unlearned behavior is fundamentally a quantitative one. A comparatively few localized reflex arcs constitute the basis of reflex behavior; a larger number of reflex arcs acting to orient the organism in space is present in tactic behavior; and a still greater number of reflex arcs are involved in instinctive behavior. According to Loeb, an instinct is based on "a system of chain reflexes." Herrick and others recognize no clear-cut boundary between reflexes and instinctive actions.

Reflex behavior is a relatively simple involuntary response to a local stimulus involving usually only a part of the organism. The reflex type of behavior may vary in complexity, depending on the number of reflex arcs involved.

A reflex arc is the nerve pathway a stimulus (nerve impulse) takes from the sense organ or receptor to the central nervous system over an afferent nerve, and over an efferent nerve from the central nervous system to the muscle or effector. There are

* Except in protozoa and porifera, which have not evolved a nervous system. In such cases—as in plants—unspecialized protoplasm is capable of transmitting stimuli.

many examples of simple and complex reflexes. Some examples of reflex behavior are the pupillary reflex, which regulates the size of the pupil according to the amount of light passing through it. There are various tendon reflexes, such as the patellar reflex or knee jerk. A type of reflex behavior which is useful to the organism is the withdrawal reflex or defensive reflex which attempts to withdraw the animal or its parts from any painful or destructive stimuli.

Tactic behavior is a specific orientation movement of the organism as a whole in response to certain environmental stimuli. The position of an organism in space is determined in such cases by the surrounding field of stimuli. Animals moving toward the source of stimulation exhibit a positive taxis; animals moving away from the source of stimulation exhibit a negative taxis.

Wheeler states that an instinctive behavior is a "more or less complicated activity of an animal acting as a whole rather than a part, acting as a representative of the species instead of as an individual, acting without previous experience or modification caused by experience and toward an end or purpose of which it has no knolwedge."

Watson defines instinctive behavior as a series of concatenated reflexes which unfold serially upon proper stimulation. There are innumerable instances, especially among insects and birds, in which reflexes occur in series. The first directly called out by some appropriate stimulus, usually external, itself becomes the cause of another which follows it, and so on through a series involving variable numbers of reflexes. These are often called *chain reflexes*. A chain reflex is an inherited type of reaction and may involve so many reflexes that the behavior will appear so complicated and purposeful in character that even the experienced observer often wonders whether rational or intelligent behavior is being expressed. Many adaptive behaviors are apparently so complex, that the physical basis involved is so intricate a reflex pattern, that it defies analysis.

Simply stated, the behavioral actions which we call instinctive are inflexible responses performed untaught, and are usually adaptive in nature.

At this point it may be instructive to cite an example of unlearned behavior involving at once all three of its constituents, namely, the *reflex*, the *taxis*, and the *instinct*. The influence of structural organization and physiological state should be noted.

The caterpillars of the goldtail moth, *Porthesia chrysorrhae*, hatch in autumn and spend the winter hibernating in nests near the ground on the stems of the shrubs on which they feed. In early spring they leave the nest and crawl (crawling involves a series of reflexes) straight up the shrub to the tops of its shoots, where they find the first buds beginning to open, and these they devour. The coming out from the nest is apparently a response to warmth, for they can be made to leave it at any time in winter by warming it artificially. But why do they crawl upwards; how do they know that the only place where they can find food is at the tops of the branches? If they went downwards, they would starve.

They do not know! This upward creeping can be shown to be a simple positive response to light directed by the light reflected from the sky. If some of the caterpillars are taken as they are leaving the nest, and put in a glass tube lying near a window, they will all collect at the end of the tube nearest the light, and stay there. If the tube is turned around they will crawl to the other end, again towards the light, and wait there. Most surprising of all, if a few of the young leaves from their food-shrub are put at the other end of the tube, the end farthest from the light, they make no attempt to reach the meal; the light rays hold them captive at the end nearest the window, and there they stay until they starve.

Under natural conditions the taxis guides them up to the only place where they can find their food. But there is a further complication here. For only an unfed caterpillar responds positively to light (effect of physiological state); in some way nourishment removes the taxis, and after the caterpillar has eaten, light has no effect. The utility of this is clear. The caterpillar quickly clears up the leaves at the top of the twig, and if its slavery to light persisted it would have to stay there and starve. Having eaten, it is freed and can creep in any direction; the experiment with the glass tube and window now gives no result. So it is able to work its way downward and find the lower buds as they begin to open. We see in this example of a complicated instinctive behavior the combination of a series of reflexes making possible a tactic response and the further combination of both of these resulting in complicated instinctive behavior all three of which are affected by the structural organization and physiological state of the organism.

THE PREPARATION OF TEACHERS OF GENERAL MATHEMATICS*

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In a discussion of this topic it would seem necessary to define the quite confusing term, general mathematics.

From a very fundamental point of view the subject of arithmetic best illustrates the idea embodied in general mathematics. For if arithmetic is taught as a subject of thought, meaning and understanding it must finally be general and not specific. For example, in the very earliest stages, when the child is learning the meaning of number, he is learning a generalization. The idea of three grows out of many specific groups each having three objects. Three apples, three chairs, three boys, three anything finally lead to threeness. Again the child learns that two apples and three apples are five apples. This particular combination is repeated many times with a change of units. And when the child is able to appreciate that two and three are five, he is learning a bit of truly general mathematics. Of course arithmetic is also a subject of skills and techniques which must be mastered. Its method is inductive always working from concrete situations to the general. Even though the term, general mathematics, implies something else for us today, it is well in the interest of good teaching in grade school to emphasize that generalization should finally become one of the goals of all teaching of this subject. In fact, I believe the chief fault of our teaching has been that we have dealt too much in skills, techniques, and devices for answer getting rather than in reaching generalizations, meaning and understanding.

General mathematics is also used to describe the organization often found in junior high schools in grades 7, 8, and 9. This type of mathematics is not the old compartmental type of organization which treats arithmetic, algebra, geometry, and trigonometry as distinct, unrelated subjects. The struggle toward a better more unified organization had its beginning back in the very early part of the century. The very famous presidential address of Professor E. H. More in 1902 before the American Mathematical Society has profoundly influenced this movement of coordination. Mathematicians and Educators in

* An address delivered before the Mathematics section of the State Teachers Association, Nov. 3, 1944 at Kansas City, Mo.

Europe also about this time were urging this new approach. This new organization looked toward a mathematics which would enable the pupil to see units of mathematics as a related whole and thus give him a more comprehensive view of the whole field of elementary mathematics. Thus, arithmetic, algebra, geometry, and the beginnings of trigonometry were treated as a unit called general mathematics. Other terms used were correlated, fusion, and integrated mathematics, In this new unit it was the intention to bring together the important interrelations of the various subjects, whenever it was possible. The very far reaching Report of the National Committee of 1923 and the later Report of the Joint Commission of 1940 both emphasize and urge this organization of mathematics for grades 7, 8, and 9. Many schools are teaching this kind of mathematics with fine results.

In view of this emphasis from leaders of mathematical education it is difficult to explain why many junior high schools do not employ this unified approach to mathematics rather than clinging to arithmetic, algebra, or geometry as distinct subjects. In fact, when teachers are selected with better preparation the work in mathematics of grades 7, 8, and 9 in all schools should be organized along the plan suggested by the two national reports previously mentioned.

The very great increase in the high school population in recent years has resulted in a large group of students who have no interests in real school work. They do not expect to go to college, and a very great number will quit school before college is reached. A few will lack native ability to do genuine school work. A few through poor teaching in the elementary school will find it difficult to study algebra and many other subjects. To meet the needs of this large number of pupils a one year's couse for grade nine has been organized in many parts of the country. This course was also organized to meet the demands of many administrators and teachers from the field of professional education, who, for many years have condemned the presence of algebra and geometry in the high school curriculum. It is described in the Report of the Joint Commission as a "composite course consisting of arithmetic, algebra, trigonometry, social mathematics, geometry, and logarithms." This is a terminal course and it is usually labeled in the United States general mathematics.

In 1941 the State Department of Education of Missouri issued Bulletin number 5, in which is outlined the work of grade 9 under the heading, general mathematics. This outline does not have quite as much mathematics as is suggested by the Joint Commission, but a study of many texts reveals that some informal geometry and some work in algebra are included. This type of general mathematics and all such courses purport to emphasize applications, concepts and so-called practical mathematics. It does not stress logical organization of subject matter. It should remedy very great weaknesses often found in arithmetic. Students who are found capable should be urged to continue their study of the more formal algebra and geometry. In fact, the most glaring defect of this "general mathematics" is that many capable students are not urged to continue their study of formal mathematics.

The teacher is always more important than the particular method of organization. It has been a very popular sport of professional educators for many years to condemn mathematics as a subject not worthy of a place in a high school curriculum. Had these well meaning gentlemen been more astute, they would have condemned the teachers for teaching mathematics in such a poor manner. An excellent teacher with most any kind of curriculum organization will produce helpful results. A poor teacher with the very best type of program will fail to secure good results.

It might also be mentioned that a fundamental flaw in our educational procedure has been that we have made courses and requirements for graduation of courses with high sounding names, lofty objectives, and have utterly failed to see that good teachers were provided. There can be no substitute for a fine teacher. Our fine phrases of educational objectives are worthless unless good teaching is provided.

A teacher is a combination of personality, knowledge of subject matter, and its importance and should possess skill and have a great interest in young people. The teacher should also have the ability to lead or guide young people in the quest of learning. Hence, the most important question in the teaching of mathematics is the preparation of the teacher.

When this course of general mathematics was being organized over the country many administrators, observing that the mathematical content was very meager in fact, scarcely more

than the application of arithmetic, at once decided that any teacher on the staff could teach the course, the only prerequisite being that the particular teacher had a vacant period. People who could not balance an expense account, had no hesitancy in attempting to teach this course. If a system had more than one teacher, the one with the poorer qualifications was assigned to teach general mathematics. What does it matter, thought the administrator? These children for the most part have no interest in any academic studies. This attitude is a half-hearted attempt at education. People who pay the tax bill for education have a right to expect teachers to take seriously the education of their children. These youths can be given something worth while. Many will decide to continue their studies. If we are to continue this method of indifference to preparation, of giving grades where there is no attempt at learning, if we are to "goose step" everybody through to graduation, then the chief purpose of the teacher should be to entertain the children while in school.

Education should be a serious enterprise. The poorest boy or girl, the one with little promise, also the gifted boy and girl—all should in view of the need for life preparation have a chance for the real development which comes through good teaching. We boast of our educational system, or we did until the war revealed very glaring weaknesses. We really have a right to boast when we think of the number going to school and the very elegant plants in most cities and many villages. We can boast of the musical development of our youth. But in the realm of good English usage, history and its meaning, and arithmetic along with other mathematics and science, we need to re-evaluate our results, to restudy our teaching. We have been found wanting. Many in public life realize this. We, the teachers, must lead the way by real, genuine, teaching.

It is on the assumption that we in the future will take education seriously that I make bold to list some qualifications of a teacher of ninth grade general mathematics. I should not want to vary these qualifications very much for the teacher of more formal mathematics, and but very little if any for the teacher of the 7th, 8th, and 9th grade mathematics, organized as general mathematics.

If there be two teachers in a system of equal academic preparation, of equal cultural outlook, of equal professional skill, but if one has greater teaching ability, then this teacher should be assigned the general mathematics course. This group needs

the master teacher. It takes great skill to integrate in a splendid way for future living the several types of mathematics in this course. It takes one of wisdom of experience, of wide scholarship in many fields, to teach general mathematics in an interesting and useful manner. It will be far more difficult to teach general mathematics than to teach algebra and geometry. The teacher qualified for the former should be well prepared to teach the formal mathematics but the converse is not necessarily true.

To teach general mathematics in an effective way the teacher should know mathematics quite well through the calculus. Calculus is a unifying subject in itself and it is also general mathematics in that all previous branches of mathematics are found in it. Its mastery is almost necessary to guarantee a knowledge of elementary mathematics. For one to teach successfully a course which interweaves several subjects the teacher must know how this coordination takes place. Thus in a very simple equation there are concepts from geometry, algebar, trigonometry, and analytic geometry. All of these concepts become unified in calculus. A knowledge of calculus will place the teacher several steps ahead of the pupil, and this is necessary or we will see the spectacle of the blind leading the blind.

The course now offered in many colleges called Modern or College Geometry should be a requirement. Our high school course in plane geometry has been so weakened that it does not furnish the teacher with a background sufficient for successful teaching. College geometry also gives a teacher a larger perspective and a different view point of present trends in geometric thinking.

The teacher also needs to be very familiar with the applications of mathematics, for this course should have direct utility in the lives of children. The world today is full of mathematical applications. It is also full of people trying to teach these applications who have very scant acquaintance with the mathematics back of these applications. If the education for war requires many weeks in giving the background of mathematics and physics to the student of aviation before giving him the instruments and the mechanical methods of flying, is it not more important that we give a background of understanding and meaning to the applications of mathematics to life today? We need to learn meanings and theory before we can apply learning in life situations. If all our future problems could be

known in advance, we could get answers for them. We must develop thinking and resourcefulness for the unheard problems ahead.

The professional development of a teacher of general mathematics is of greater importance than for the teacher of the formal mathematics. We have not given enough attention to this aspect of education, which is only secondary to the academic preparation. We have almost quit giving courses in the Teaching of Mathematics in our colleges. Such courses are needed to study the future problems of the teacher. The curriculum problem is one of the fields for exploration. Much has been written on the retarded pupil. More needs to be studied to cope with the brilliant pupil. Psychology has a contribution to make to the teacher. An acquaintance with several fine magazines, year books of the National Council of Teachers of Mathematics, and work done in foreign countries will yield help for the alert teacher.

In the group taking general mathematics, especially if no chance has been given for a classification of students into groups according to ability there will be found the retarded and unprepared pupil, the students with little or no interest in any school work, and also the average as well as the very capable student. To keep a challenge before such an array of talent requires high skill and knowledge of youth. Always in such a group will be found a few who will be good students in spite of teaching. Also there will be many who will respond only where real leadership is in charge. Too often in recent years we have let the dull and indifferent determine the tempo of instruction. As a result of this many a bright youngster has had no challenge. His interests have flagged and in many cases his talents have gone undiscovered. It will require a teacher of great ability to give the dull and indifferent something worth while and at the same time to encourage the capable pupil to do his best.

Thus the preparation of the teacher should give the ability to know the student, to discover his latent powers and to match these powers with a challenge which will result in his growth. The motley group in our 9th grade today is one of great power and too often this power is never discovered. The indifferent, lazy boy of yesterday who seldom showed any interest in study, is often today the fine looking pilot or navigator who is flying the hump of India carrying a cargo to save civilizations or he may be the lad who has flown the Atlantic two hundred times.

If war has revealed anything it is that boys under stress have stepped forth to become our heroes. In peace it is largely up to the teacher, aided by the home, to give the urge to boys and girls to get ready for a world full of mathematics and science. In the world of peace the abiding elements are ideas, ideals, the ability to think, to do work nicely, good habits, fine attitudes. If these can be implanted in the lives of growing youth, then the teacher will be dealing in the verities. It is because real teachers of today are builders of tomorrow, that claim is justified for highest preparations.

One hears it very often from teachers of general mathematics and very often from students who have had this course that it is a makeshift course, accomplishing nothing. It is very seldom that a good word is found for it. If a real teacher is in charge the work should be helpful, but if just anybody is the teacher, who happens to be available, then the results will be worse than a mess.

One often hears some young person say that he wants to teach mathematics because it is so easy. For algebra and geometry, if the teacher knows his subject the preparation will not require as much time as for some other subject. In general mathematics the selection of material, its adaptation to students of various levels will require great labor.

The teacher also needs to be a vocational guidance expert. Much chatter has filled our air ways along this line. People out of professional schools have devised tests which they think are infallible in determining what a boy or girl should do or become in the years ahead. It would be lovely if we could foretell a boy's future through this means. In the opinion of many, the home folks and the real teacher are the best experts in vocational guidance. Hence, one good reason for any required mathematics is to enable the boy or girl, aided by a good teacher, to discover his talents. In the general mathematics this will be very important. Those capable should be encouraged to advance. The world of science, demanding a knowledge of mathematics, will increase with the years. The contribution of mathematics to the thinking and personal development is always one of its most important values, hence the teacher who can discover a capable pupil and properly advise him, is rendering a very great service.

Many a boy and girl now goes to college with a desire to prepare for work involving mathematics. This is often denied him because he had no algebra and geometry in high school. The

teacher who is wise toward many things needed by boys and girls and the school, which is forward looking enough, to provide proper courses of instruction for them are the supreme needs in education today.

The preparation of teachers will depend upon what is to be accomplished. It may appear that what is suggested is only a dream. Of this we may be sure. Better work must be done in the public schools, yes also in the colleges. The public is already aroused when it sees young people going to college with scarcely any preparation at all from high school. There has been no complaint that credits on the book have not been given. But the real ability to think, to write, to organize, to do work well, all are too often lacking. The public knows the situation is bad. Often I believe it knows the situation as well as the administrator. The cost is great, the results are not satisfactory. We must produce results to balance the cost.

We are in a day when preparation of teachers has reached a new low. Just most any one who can be persuaded, is now allowed to teach. This day will soon pass, and the teachers who left school rooms will soon be returning. Somehow the public needs to realize the great need for greater teachers. Salaries which will give the profession a decent respect among other professions should be given but only for better prepared teachers. We teachers and public, have scarcely taken our school work seriously. The public has been willing to endure teachers not prepared at very low salaries. Hence our most capable go into other fields. It is only when a great service is rendered that we can demand salaries comparable to what engineers, lawyers and physicians get. So this is the dream. Let us prepare teachers for real leadership and give them salaries to equal the contribution.

Finally, the preparation of teachers is a task that will never end. The teacher must always learn about her profession even though college and university days are past. Growth through contact with teachers must continue. The real teacher must be aware of studies in the field and be willing to make investigations. We have often done it in a little way. There is no greater work than to aid in the personal development of children. This is always the greatest task of the republic.

Promote, then, as an object of primary importance, institutions for the general diffusion of knowledge.—George Washington.

SCIENCE TEACHING AND SCIENCE CLUBS NOW AND POSTWAR*

WATSON DAVIS
Director, Science Service, Washington, D. C.

Science and mathematics teachers have an immense responsibility in this troubled world.

For more and more we are coming to see that the methods of science and mathematics must not be confined to the schoolroom.

The precise methods of mathematics and the searching habits of science must penetrate into English, history, language, social studies; must permeate every line of our thinking.

The experimental attitude must prevail: courses must be taught experimentally, the teacher must be experimentally-minded in a perpetually unfinished, experimental world.

For human beings must learn to think straight—human beings must learn to think scientifically—if the world is to be rescued from the plague of intolerance, emotional ignorance and injustice that afflicts it.

The war has shown us—if we did not know it before—that modern civilization is based on creative and aggressive application of science.

We know now that diluted and distorted science courses are outmoded. Our very survival in a world of science is based upon our ability to keep up with the changes that occur so rapidly and to keep ahead of the social consequences that befall the laggards in this world of science.

Only the most sincere and truthful and ardent science teaching will produce youth that will insist in their adult life on science instead of superstition, on fact instead of hearsay, on experiment instead of chance, on planning instead of speculating.

An intelligent citizenry can come only from years of training. But our struggle upward toward the truly democratic way of life is based on the ability of every citizen to know and apply the scientific method of thinking to daily life. And on you science and mathematics teachers rests a responsibility to mold this kind of citizen.

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* Based on address before the Physics Section of the Central Association of Science and Mathematics Teachers, Chicago, November 24, 1944.

This is no easy task. We at Science Service have been striving for this since Science Service was endowed 24 years ago, with the express purpose of popularizing science and its methods through the press. We can tell you that scientists themselves often fall far short of employing their well-learned scientific methods to their own driving or shopping or voting. But through these 24 years we have witnessed the slow change that has made scientific knowledge more and more the property of every man (rather than just the cloistered few) and in time, through your efforts and ours and the hundreds of other forces at work, we may see the emergence of citizens informed and intelligent enough to drive, shop or even vote scientifically.

I have just returned from a 14-day flight as a U. S. war correspondent in which I covered 6,510 miles in 37 flying hours. When I alighted at Washington's National Airport day before yesterday (Nov. 22), I had seen bases of the Army's Air Transport Command in Greenland, Iceland, Newfoundland, and Labrador.

I had talked with young men, your students only a few years ago, who stop off at Labrador, Newfoundland, Greenland or Iceland on their way to Europe, as casually as they used to stop at the corner drugstore for a coke after school. They argue over the achievements of their big bombers and transport planes with the same earnestness they used to devote to their latest radio sets and their chemistry experiments. They have mastered their present assignments in large measure because of those years of experience with machines, gadgets, experiments that you helped them to get.

They will return to a civilian world which they will expect to move with the same clock-like precision that controls their flights now. They will be prepared to master the new in science as quickly as they have adjusted themselves to it in wartime. It is you now who must keep up with science; who must speed up your methods to keep pace with a world that your students and your graduates accept as normal.

To cope with the tremendous enthusiasm of youth for science and the high speed of scientific events you have at hand an assortment of teaching tools that are constantly improving:

Textbooks on the basic sciences and the many branches of science are written and beautifully illustrated with the aim of making the acquisition of information as painless as possible for students as well as teachers.

Books on science are presented with the color and glamor of novels.

Exhibitions are accessible and attractive.

Museums cater to the taste of youth with the new "do-it-yourself" plan of presentation.

Radio Programs intersperse their lighter moments with useful up-to-the-minute news reports and talks that tend to keep the public informed on science without being conscious of teaching.

Newspapers and Magazines play their part in whetting the appetite of the student for the hardier fare you have for them in the classroom. And newspapers and magazines are your way too of keeping up with science that is too new for the textbooks you are using. So much happens every day in the world of science that our staff of science writers at Science Service must condense and cut it with the utmost care to be sure that the most important events are reported to the newspapers already overfull with war news, most of it of a scientific character. And each week when the *Science News Letter* is prepared we must cut again and condense in order to get into the space requirements of our weekly magazine the top news in science for that particular week.

In spite of all the assistance you get from textbooks, books, exhibitions, museums, the radio, the press, magazines, transcriptions, motion pictures, charts, diagrams, handbooks, models and dozens of other teaching aids that you have adapted for your use, the average science teacher is still literally swamped with the task of keeping up with the fast moving world of science and the overwhelming, avid craving of the student for more information.

We have been in a position to watch this striving on the part of you teachers to keep ahead of this flood which almost threatens to engulf you at times and have attempted to do what we can to help you in the gigantic task that faces you in the administration of a job which you and we think should be done well.

To the servicing of science news daily to the press of this country, which was the initial purpose of Science Service, we added in 1922 the *Science News Letter* to summarize the science news weekly for you in magazine form. In 1940 we added THINGS of science by which we attempted to send you monthly actual samples of new things in science with adequate explanations and suggested experiments so that you and your students

could see, taste, smell, sample and experiment on new things of science often before they were on the market.

We watched with growing interest and admiration what you were doing with science clubs. We noted how you were giving your better science students a chance to do more than just classroom work by staying after school hours for individual and group instruction in beyond-classroom science activity.

In 1941 we decided that we might be very useful to you in this educational venture and we added SCIENCE CLUBS OF AMERICA to our many activities for the popularization of science.

The declaration of war later that year gave added impetus to our efforts as you and we mobilized our forces for greater coverage of the all-necessary science that is winning our fight with the enemy.

From our experimental beginning we have progressed now to the place where we feel we can point with some justifiable pride to this new Science Service. SCIENCE CLUBS OF AMERICA is now composed of close to 6,000 science clubs. This means that 6,000 science teachers, mathematics teachers, professional scientists, fathers, scout leaders and other such adults are working with us to provide opportunity for boys and girls who want to learn more about science than the classroom alone has time to give them. About 150,000 young men and young women are in this national organization of science clubs because each club averages about 25 members.

Our original plan—which we have tried to adhere to throughout—was to supplement science classroom teaching—not supplant it. We desired to help you give your better science students something beyond what you have time to give them in the classroom. We had no desire to tell you how to teach, as you had devoted your life to learning that, but we did try to make it easy for you to get hold of extracurricular materials that you could give directly or indirectly to your science students.

We built our assistance into the club plan because we knew that you had had success with it and we were aware that clubs are appealing to youth. We sought to encourage group effort in science because we felt that it is more desirable than individual effort and that students would do well to learn as early in life as possible that science information gained by individuals must become the property of the group in order to be retroactive.

So many of you are familiar with SCIENCE CLUBS OF AMERICA

that it is only necessary to review very briefly the materials we have prepared up to now for the use of our 6,000 clubs.

We prepared a basic manual on "How to Organize and Activate a Science Club," and then accumulated all the things that science clubs could do and prepared another manual on "1000 Projects for Science Clubs." We prepare an annual listing of science books to make it easy for you to add to your science club library. We have gradually obtained and reviewed advertising materials until this year we have been able to issue a bulletin on "Free and Low Cost Materials for Science Clubs." This contains excellent material to be obtained free or at small cost from 247 companies and organizations usually with no more effort than the writing of a post card.

We enlisted the assistance of already established organizations such as academies of science and science teachers organizations and are pleased to report that at the present time we have the honor to be working with 31 different professional science groups in 28 states. These cooperating organizations are providing local impetus to the job we are trying to do on a national scale. Their close proximity to the club itself gives the enormous lift of personal contact with real live scientists that the young scientists find so gratifying. The academies of science are giving us very valuable assistance by suggesting ways of making the science club program most effective on a state and national basis.

Our latest venture in SCIENCE CLUBS OF AMERICA is called SCA Co-Projects and I want to tell you a little about that because it is very exciting to us and because it shows in a measure how much this organization has grown in the four years of its existence and how much it may be able to do in the future.

We have always felt that experiment for a purpose is more effective than repetitious experiment. So this year we set out to find some jobs that these able 150,000 boys and girls could do while they learned their science in their science clubs. The organizations we approached were overjoyed with the prospect of assistance in these days of labor shortages and we had no difficulty in convincing them that SCIENCE CLUBS OF AMERICA members could be useful to them.

The National Aeronautic Association needed surveys done for the airports we must have when civilians can fly again at will. The Forest Service needed deputy fire wardens and forest conservationists by the thousands. The Federal Bureau of Investigation was delighted to enlist more recruits who by becom-

ing informed could offset the wave of juvenile delinquency that is so sure to come after the war. The U. S. Weather Bureau saw in these thousands of clubs an opportunity for doing a job that has long been needed but lacked personnel. Now thousands of trained boys and girls will collect data on rainfall which when compiled by the Weather Bureau will help to solve the mysteries of storms. The clubs have been asked to collect milkweed floss, to plant cork oaks to prevent our dependence on foreign imports, to learn about nutrition so they can educate their communities on how to eat for better health. They have been enlisted in the fight against cancer, have been called upon to become conservationists of fish and wildlife and many other scientific tasks in the 13 Co-Projects.

If the club members are able to fill these much needed jobs (and we believe heartily that they can) we will work out other Co-Projects so that the members can contribute to the world of science even while they are learning science.

An outgrowth of SCIENCE CLUBS OF AMERICA is the ANNUAL SCIENCE TALENT SEARCH. This was planned specifically for the upper 10% of your students who show great talent for science and should have an opportunity to go on with formal training in science beyond the secondary school level. We are now in the midst of the FOURTH ANNUAL SCIENCE TALENT SEARCH. We expect as before to have at least 15,000 high school seniors compete. In each of the past three years only about 3,400 of these have been able to complete all the requirements of this very stiff competition, and of that number we have picked 300 and named them for Honorable Mention. These we have recommended to colleges, universities and technical schools as top-ranking science students. Scholarships have been forthcoming from those institutions in such quantity that some students report they have been offered as much as $3,800 worth of scholarships. From the 300 Honorable Mentions we select 40 to bring to Washington for five days of the Science Talent Institute where we present to them outstanding scientists who give them a picture of the world of science for which the 40 are preparing themselves. During their visit to Washington $11,000 in Westinghouse Science Scholarships are awarded to them ranging in size from $100 to $2,400—all of them generously donated by the Westinghouse Electric & Manufacturing Company.

To check on the effectiveness of the SCIENCE TALENT SEARCH, which is an experiment without precedent, we have set up a

mechanism for following the careers of all those who have participated in the contest. At the present time this amounts to approximately 9,000 young men and young women, some of whom we fully expect will be famous scientists of the coming years.

This paper would not round out the rather rotund subject assigned me without going into our postwar plans for SCIENCE CLUBS OF AMERICA.

We hope to see this organization of young scientists increase in numbers. We hope to see the science club idea spread into the elementary school as it has already spread in the junior and senior high schools. We hope to see the science club idea spread into the college, university and technical school and we have very sincere hopes of starting it among adult groups when the cessation of war restores time for hobbies.

We already have working with us science clubs in U. S. possessions and in a number of foreign countries. When the war is over we hope to expand the number of clubs abroad and we hope to be able to carry out a plan of ours for exchange of correspondence, equipment, specimens, and so forth, between clubs in this country and clubs abroad.

We think our Co-Project idea is going to be worth expanding. When students have more after-school time considerable vocational guidance can be gained through the Co-Project method of job sampling.

We plan to continue the SCIENCE TALENT SEARCH and will be guided in our administration of this by our very careful studies of the careers of those who have been affected by it. The first of our scholarship winners are going to graduate this next semester from college and we are as anxious as an old hen about their future achievements.

We think the promise of FM radio offers possibilities for SCIENCE CLUBS OF AMERICA in the operation and also in program production of science broadcasts.

We want to encourage investigation of science locally and have plans for exploration of community science: the archaeology and paleontology of your town; the folk-ways of your area —your songs, lore, plays, foods and community history. We believe that America, new as it is, has only scratched the surface in the study of the science in its own back yard. We want to encourage clubs to open their eyes to the opportunities at home.

Our association with science teacher organizations, academies

of science, museums, and so forth, have revealed to us many opportunities for the expansion of opportunities for young scientists which must now be curtailed because of transportation difficulties. But when the war is over we have plans for encouraging science activity on a local basis among students as young as 10 and continuing up into the adult hobby groups.

And our postwar planning will include watching the science and mathematics teachers of America for other ideas as good as science clubs.

HEALTH CENTERS IN EVERY COMMUNITY

Health centers in every community, Federal grants-in-aid to states for postwar construction of hospitals and medical centers and for extension of public health services, and federal scholarships or loans to assist medical and dental students are among the steps toward solving the nation's medical care problem recommended by the Senate subcommittee on wartime health and education.

The proposals are made in a report of preliminary findings by the subcommittee, which consists of Senator Claude Pepper, of Florida, chairman, and Senators James M. Tunnell of Delaware, Elbert D. Thomas of Utah, Robert M. La Follette, Jr., of Wisconsin and Kenneth S. Wherry of Nebraska.

The problem of how to pay the doctor's bill must be solved by some form of group financing, the subcommittee reports, but it does not make any specific recommendations on this point.

Voluntary or compulsory health insurance, use of general tax funds or a combination of these, are presented as possible ways of solving the problem.

The heavy losses in manpower to the armed forces and industry because of defects, injuries and illness, brought out in hearings before the subcommittee, are stressed in the report. So are the achievements of medicine and the need for more and better-distributed medical facilities and services.

THE UNKNOWN TEACHER

I sing the praise of the unknown teacher. Famous educators plan new systems of pedagogy, but it is the unknown teacher who delivers and guides the young. He lives in obscurity and contends with hardship. He keeps the watch along the borders of darkness and makes the attack on the trenches of ignorance and folly. Patient in his daily duty he strives to conquer the evil powers which are the enemies of youth. He awakens sleeping spirits. He quickens the indolent, encourages the eager, and steadies the unstable. He communicates his own joy in learning and shares with boys and girls the best treasures of his mind. He lights many candles which, in later years, will shine back to cheer him. This is his reward. Knowledge may be gained from books; but the love of knowledge is transmitted only by personal contact. No one has deserved better of the Republic than the unknown teacher.

HENRY VAN DYKE

SQUARE ROOT

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The teaching of square root gives the pupil, at best, the mere mechanics of a method which is of little or no practical value in view of the accessibility of tables of square root. At the same time it fails to take advantage of an excellent opportunity to illustrate the power and simplicity of algebraic analysis. The present paper attempts, therefore, to indicate a procedure which emphasizes typical algebraic reasoning on the level of the average pupil.

As in all cases where the teaching is purely mechanical the residue which remains in the minds of even the more successful students after a short time is disappointing. It is, for example, revealing to ask students in teachers' courses to "state the reason for doubling the part of the root already found!"

The closest approach to an explanation which is to be had is that the root is doubled because there are two factors. Properly understood, this is the heart of the explanation. Invariably, however, those who volunteer the two factor hypothesis are unable to supply further detail or to give evidence of any understanding.

Their reasoning, which is typical, consists in assuming that if two facts are concomitant, such as two factors and doubling to form the trial divisor, the one is the explanation of the other. That students can be satisfied with such reasoning is due to an overemphasis on the inductive method throughout grade and high school.

If we turn to the textbooks and note the way in which square root is presented, it is easy to see why students fail to acquire a real grasp of the subject.

A favorite explanation device—the writer recalls it from his 8th grade arithmetic[1]—consists of a square piece of wood, bordered by two identical rectangles and a small square in such a manner as to form a larger square. Square root was explained by showing that the side of the latter could be computed (approximately) by dividing the ***difference in the area of the two squares (the bordering area) by twice the length of the inside one.*** The explanation seemed both clear and interesting. The diffi-

[1] Since the explanation of square root turns on $(a+b)^2$ it is clear that this topic should not be introduced until the student has had one or two semesters of algebra.

culty came in transferring the square and its bordering rectangles to arithmetic numbers. The writer must confess that he was unable to make the transition. From this point on he had to content himself with trying to understand the mere mechanics of square root.

In the blackboard drill which followed, most of the class managed to "catch on" to the routine, though "zero difficulties" were and continued to be a stumbling block. In this manner a degree of mechanical ability was achieved without any accompanying understanding.

The experience cited is typical of the difficulty which we get into when geometrical illustrations are employed. It is true that they make a vivid appeal. Pupils will remark that "now they see the explanation." This is such an unusual and pleasant reaction that it is small wonder that teachers become enthusiastic and bring in geometric and mechanical illustrations on every occasion.

There is here, however, a very serious confusion on the part of both teachers and pupils. They assume mistakenly that understanding, or "seeing," the geometric illustration is equivalent to understanding the algebraic, or arithmetic, problem. They forget that there still remains the question, how to get from the one to the other? This may, and frequently does, prove to be as difficult as the problem with which we began. In this event the geometric illustration will have served merely as a pleasant excursion which leaves the task of explanation awaiting us on our return.

It is the writer's conviction that the central core of reasoning in algebra, and arithmetic, should be in terms of numbers, literal or numerical, or both. The geometric and mechanical illustrations should be assigned a secondary role and only brought in as interesting supplementary material—a form of intellectual play which follows the explanation instead of preceding it.[2]

In 9th grade texts we are likely to find the geometric square replaced by

$$(a+b)^2=a^2+2ab+b^2.$$

The procedure consists in showing how to recover $(a+b)$ from its square and thus arrive at the square root algorithm.

The following is an illustration of the method,

[2] E.g. The balancing of weights in the two pans of a weighing scale should be secondary to the idea of adding the same number to both sides of an equation. In general, problems of application are merely illustrative material from the mathematical standpoint.

The given square $=$	$a^2+2ab+b^2$	$\lvert a+b=$ sq. root
The square of a $=$	a^2	
Trial divisor $=2a$	$2ab+b^2$	
Complete divisor $=2a+b$	$2ab+b^2$	
	0	

Step 1. Take the square root of the first term a^2, as the first term of the root.
Step 2. Subtract a^2 from the given square.
Step 3. Etc.

This explanation is in terms of numbers. But the fact that they are exclusively literal makes the transition to arithmetic number difficult. The choice of notation, too, is unfortunate. It has as a fault what is usually regarded as a virtue, namely, perfect symmetry in a and b. Having at the outset treated these letters on a par notationally, it is thereafter very difficult to emphasize that (a) is the part of the root already known and (b) the part remaining.

In connection with this type of explanation, the writer has frequently been unkind enough to ask prospective teachers why (a) and (b) are dragged in whenever we wish to discuss square root. What is the significance of the a? of the b? It is difficult to find a student who knows.

In some textbooks t and u, representing tens and units respectively, replace (a) and (b). The objection to the "t and u" explanation is that it obscures the main issue by emphasizing what is essentially a secondary matter, namely, the decimal structure of the number system. This is the same error which we make in teaching logarithms to the base 10 from the start, when any other base, 2 e.g., would not be so specialized.

In all these explanations—geometric square, $(a+b)^2$, $(t+u)^2$ —there is evidence of haste to reach the formal process. The pupil is convinced of the correctness of the method but fails to understand it.

In this respect the present day teaching of square root is similar to that of transposition some years ago. The writer distinctly remembers teaching transposition as a *formal* topic. Teachers will recall the familiar, inductive procedure which consisted in showing that numbers which disappeared from one side of an equation reappeared on the other side with signs changed. When a sufficient number of examples had been worked out, the rule was announced and thereafter made the basis for solving equations.

As is well known, transposition is no longer taught in this manner, but on the contrary students arrive at the principle as a casual observation in connection with the basic method of adding to or subtracting from the two members of an equation.[3]

To bring about a similar development in the teaching of square root is the object of the present paper.

The following explanation taken from a well known algebra text is less abstract and therefore more understandable than the one based upon the square of $(a+b)$.[4]

Ex. 1. Find the square root of 1296.

Solution. We first notice that the square root of 1296 is between 30 and 40 because

$$30^2 = 900,$$
$$40^2 = 1600.$$

We are to find a number between 30 and 40 whose square is 1296. Then

$$(30+n)^2 = 30^2 + 2\cdot 30n + n^2 = 1296.$$

We can write this work as follows,

$$\begin{array}{rrl} & 1296 & 30 \\ 30^2 = & 900 & — \\ \hline & 396 & = 2\cdot 30n + n^2. \end{array}$$

Subtracting 30^2 or 900, from 1296 we have left 396, which represents $2\cdot 30n + n^2$.

We know that n is a number smaller than 10. If we divide 396 by $2\cdot 30$, we find that n is 6, plus a small remainder. We can set down 6 as the value of n, hence

$$\begin{array}{lrll} & 1296 & 30+6 & \\ & 900 & & \\ \hline & 396 = 2\cdot 30n + n^2 & & \text{Check} \\ 2\cdot 30 + 6 = 66 & 396 = n(2\cdot 30 + n) & & 36\cdot 36 = 1296 \end{array}$$

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[3] It may be remarked parenthetically, that the transposition principle is equally applicable to the inverse operations of multiplication and division. If, e.g.

$$x/5 = y,$$
$$x = 5y.$$

Thus a division on the left "becomes" a multiplication on the right and conversely. The transposition principle is therefore simply the observation that any of the four fundamental operations effected upon one member of an equation is equivalent to the inverse operation performed upon the other member. The reason why transposition is not emphasized in connection with multiplication and division is because multiplication by the lowest common denominator is a more useful procedure if either member of the equation consists of two or more terms.

[4] Engelhardt and Haertter, John Winston Company, publishers, 1935.

In succeeding examples the Engelhardt and Haertter explanation proceeds to a complete mechanization of the square root process.

Although this treatment is much clearer than the one based upon $(a+b)^2$, the two procedures resemble each other and the formal treatment of transposition in that they carry the explanation *straight through* to the completely mechanized process. The latter in turn serves as the method for the *first* exercise to be performed by the pupil.

A relatively difficult theory which culminates in a simple mechanical procedure constitutes a real problem for the conscientious teacher who realizes that training in reasoning is the greatest value which elementary mathematics has to offer.[5]

The difficulty with "hurrying on" to the formalized method is that the student is thus put in possession of the "answer." Add to this the fact that the theory is difficult and it becomes plain that the teacher who insists upon understanding is setting himself an almost impossible task.

In practice each of the square root explanations cited is bypassed by teachers and pupils alike. In all probability the textbook writer has no fondness for the explanation, but inserted it simply because it was traditional.[6]

The teacher, in turn, feels that he must comment on it. Perhaps he, too, mumbles something about (*a*) and (*b*). Lip service being duly rendered, the class hurries on to drill in the process.

If this proves successful, everyone is happy. Mechanical learning which has triumphed through the grades has won one more victory and the pupil complacently adds another to his long list of mathematical mysteries.

The writer proposes therefore the following explanation which may be described as a deformalized version of Engelhardt and Haertter.

For example, let us suppose that we are to find the square root of 5184. Since

$$70^2=4900,$$
$$80^2=6400,$$

70 is the point of departure. Thus the square root is $70+x$, where x is less than 10. Hence,

$$(70+x)^2=5184, \tag{1}$$

[5] This is particularly true in the present instance, since the practical value of the square root process is insignificant.

[6] This is particularly true of the method based upon $(a+b)^2$.

(2) $$4900+2\cdot 70x+x^2=5184,$$

(3) $$2\cdot 70x+x^2=284.$$

Ignoring x^2, momentarily, we can estimate the value of x by saying that

(4) $$2\cdot 70x=284,$$

so that $x=2$ approximately. Substituting $x=2$ in equation (3), we find that this value checks, so that $x=2$ *exactly* and $70+2=72$ is the required square root.

This constitutes the entire method (for the 9th grade). Following this model, pupils should have no difficulty in working any number of examples of like character. The numbers selected need not be perfect squares. It is evident that if a given choice of x makes the left member of equation (3) *less* than the right member, and $x+1$ makes it *greater*, then the second figure of the square root lies between x and $x+1$.

As a method, this procedure is complete in itself. It has several advantages. It is very simple and lacks the formal features which belong to the completely routinized scheme such as the long division set-up and pointing off by twos.

The most important advantage, however, is the fact that it exhibits typical algebraic reasoning. The square root process becomes a scheme for tracking down the unknown part of the root. As in hundreds of other algebra problems, we denote the number we wish to find by x, form an equation, and proceed to solve.

The extension to *three* or *more* significant figures and the attainment of the formal process should be reserved for third semester algebra (Algebra III). Working to three figures brings out the method in stronger relief because of the necessity of making a second choice for x.

We shall illustrate by finding the square root of 6282.

I

Since the root lies between 70 and 80 we have,

(1) $$(70+x)^2=6282,$$

(2) $$4900+2\cdot 70x+x^2=6282,$$

(3) $$2\cdot 70x+x^2=1382,$$

$$x(2\cdot 70+x)=1382.$$

Ignoring x^2, momentarily,

$$(4) \qquad 2\cdot 70x = 1382$$
$$x = \quad 9+.$$

Substituting in the second of equations (3),

$$9(2\cdot 70+9) = 1341 \text{ (41 remainder).}$$

Since $x=9$ is not enough, the square root is $79+y$ with $y<1$.

Continuing, we have,

II

$$(1) \qquad (79+y)^2 = 6282,$$
$$(2) \qquad 1341 + 2\cdot 79y + y^2 = 6282,$$
$$(3) \qquad 2\cdot 79y + y^2 = 41,\text{[7]}$$
$$y(2\cdot 79+y) = \quad 41.$$

Ignoring y^2, momentarily, we have,

$$(4) \qquad 2\cdot 79y = 41,$$
$$y = 41/158 = \quad .2+.$$

Substituting in the second of equations (3),

$$.2(2\cdot 79+.2) = 31.64 \quad \text{(9.36 remainder)}$$

.2 is therefore too small, but .3 proves to be too large. Hence the square root of 6282 is 79.2 to three places.

One or two problems worked through in this manner will prepare the pupil to ***understand and appreciate*** the compactness and efficiency of the formal process. As a step toward the latter we shall indicate the foregoing computations as follows.

$$\begin{array}{ll|l} & \text{a} & \\ & 6282 & \underline{70} \\ & \underline{4900} & \\ & 1382 & \end{array} \qquad \begin{array}{rl|l} & \text{b} & \\ & 1382 & \underline{9} \\ 2\cdot 70+9 & \underline{1341} & \\ 149 & 41 & \end{array} \qquad \begin{array}{rl|l} & \text{c} & \\ & 41 & \underline{.2} \\ 2\cdot 79+.2 & \underline{31.64} & \\ 158.2 & & \end{array}$$

The formal procedure replaces

$$41/158 = .2+ \text{ by } 4100/1580 = 2+.\text{[8]}$$

In place of c we have therefore

$$\begin{array}{rl|l} & \text{c}' & \\ & 4100 & \underline{2} \\ 2\cdot 790+2 & 3164 & \\ 1582 & & \end{array}$$

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[7] Since 41 was the remainder obtained in Part I by subtractiong 79^2 from 6282, we could have proceeded directly to eqs. 3.

[8] Annexing the next period to 41 and one cipher to 158 produces $2=10\times.2$. The 2 is, however, recorded as .2 by the "pointing off."

Telescoping a, b, c', we have

$$\begin{array}{rr|l} & 6282 & 79.2 \\ & 49 & \\ \hline 149 & 1382 & \\ & 1341 & \\ \hline 1582 & 4100 & \\ & 3164 & \\ \hline \end{array}$$

The mechanized square root process is evidently "compacted" of too many subtleties to be intelligible to 9th grade pupils. In the presence of the formal algorithm, prematurely introduced, explanation of necessity degenerates into a makeshift—a mere stepping-stone to the "final perfection."

Before concluding we shall remark that the teaching of square root compares unfavorably with that of the quadratic formula. If the latter were taught as square root is, the procedure would consist in giving a formal explanation based upon completing the square, which would lead directly to the formula.

That this is not done testifies to the fact that teachers are aware that such a method leads to mechanical substitution without understanding. On the contrary, pupils are asked to solve numerous examples by the basic method of completing the square. The formula is obtained very informally only after a considerable experience in square completion with coefficients which are increasingly literal. Such a procedure is evidently analogous to what we have suggested for square root.

In conclusion we believe that the informal teaching of square root which we have indicated is in line with accepted procedures —and that it represents a widening of the domain of fundamental, transparent method as opposed to the premature introduction of formalized algorithms which lead to mechanical work with little or no understanding.

Necessity is not the mother of invention; knowledge and experiment are its parents. This is clearly seen in the case of many industrial discoveries; high speed cutting tools were not a necessity which preceded, but an application which followed, the discovery of the properties of tungsten-chromium-iron alloys; so, too, the use of titanium in arc lamps and of vanadium in steel were sequels to the industrial preparation of these metals, and not discoveries made sheer force of necessity.—W. R. WHITNEY.

ATTITUDES TOWARD THE MATHEMATICS CURRICULUM AND POST-WAR PLANNING*

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Five years ago alert teachers of mathematics were thinking about the role of their field in the preparation for a war which for us in the United States was then two years in the future. No one knows when this war will end, but within the past year leaders in mathematical education have been turning their attention to plans for the post-war period. During the convention members of the Central Association had the opportunity to hear some of these leaders state their views. Moreover, several of them have recently published written statements on this subject. In a moment, therefore, I shall approach the problem of post-war plans from a somewhat different angle. First, however, let us look briefly at one of the trends of these last five years.

In the early stages of the "national defense" movement there was widespread recognition of the low level of achievement which seemed to characterize the majority of our students. There was also a tendency to say that boys in various branches of the military services needed "a course in algebra," or "a course in trigonometry," or some similar sort of "blanket" prescription. Then, as the situation became urgent, the "refresher" and other pre-induction courses took the spotlight. Later, as more of the time and the services of capable consultants on secondary mathematics were made available, the character of the authoritative recommendations changed. Reports and articles became increasingly definite concerning the kind of mathematics actually needed for specific purposes, so that today the minimum content is defined much more precisely than before.

As planning for the post-war period comes to the focus of attention there is substantial agreement among the writers on several points. Especially significant is the current emphasis on the importance of having the student acquire a genuine ***understanding*** of the material. In the literature, at least, it seems to be recognized that "drill on the fundamentals" is not the sole remedy for low achievement. The ***ends*** or ***goals*** to be sought, expressed in terms such as "mathematical literacy for all who

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*** Prepared for the Junior High School Group of the Central Association of Science and Mathematics Teachers which met November 25, 1944. The paper was not read because of the illness of the author.**

can possibly achieve it," are probably more universally accepted than they have been for many years. The necessity for different types of work adapted to the needs and interests of different groups of pupils has been cogently restated. The perennial need for better trained teachers and improved teaching is also clearly brought out, along with the desirability of reorganizing even the so-called "sequential" courses of the traditional academic program of studies.

It is clear, however, that the *means* by which these ends are to be reached are not, as yet, defined and agreed upon to nearly the same extent as the goals. It is also true that none of the major proposals for immediate or post-war improvements in mathematical education are in any sense new. Most of them are to be found in books and magazines published years ago. This observation is not being made here as a preamble to the proposition that post-war planning should result in many—or even any—essentially new and revolutionary recommendations. My purpose is to call attention once again to the slow pace of progress, and to set the stage for a discussion of some of the reasons for it. The paths out of the wilderness have been charted, but like the luxuriant tropical undergrowth which impedes and exhausts the jungle marcher, certain things seem to get in our way. Perhaps if we stop long enough to recognize a few of these obstacles we may find means to clear them away and thus enable us to move more easily and rapidly.

It seems to me that one of the chief obstacles that impedes progress in mathematical education consists of a tangled mass of *attitudes* or *beliefs*. Some of the attitudes are held by teachers, some by administrators, some by parents, some by pupils. A careful reading of articles in the literature will show that frequently the writers are discussing and seeking to change one or more of these attitudes. Very often, however, beliefs are emotionally charged, and efforts to change them by exhortation are unsuccessful. Moreover, a particular effort to modify beliefs may be quite logical and reasonably effective, but scattered and unorganized efforts of this kind are usually less effective than a systematic program designed to bring about changed attitudes.

Attitudes or beliefs tend to cluster around certain problems or issues. Thus we find a complex of attitudes associated with the so-called non-academic program, courses in general mathematics, and related problems. In *The First Report of the Com-*

mission on Post-War Plans there is one paragraph which bears directly on this question. It reads as follows:

"... This differentiation should be done without stigmatizing any group. In far too many schools, the mathematics program has been seriously weakened by the general impression that the traditional courses were the *only* respectable ones, and that successful completion of them implied prestige and acceptability. How can we avoid stigmatizing the more general and the more practical courses? We can do this by making clear to pupils that the courses have different goals and different experiences for people with different interests, by taking more into account than the scores on intelligence tests when classifying a pupil, for example, his ability and his desire to do the course at a fine level; and by removing the halo from the traditional courses. The sequential courses will always command respect because they are rightly associated with admission to professional schools requiring technical courses, but this fact need not and should not imply disrespect for the other courses."

Here we have explicit recognition of the fact that attitudes must be considered if certain recommendations are to be effective. Also several suggestions are given for dealing with these particular attitudes. There is, however, much more to be done along these lines.

A beginning might be made by collecting from teachers, students, and others, statements of their views or opinions on a given topic—say, present courses in general mathematics. We could expect to obtain statements like those that follow.

(1) "If a student has the necessary ability, it is better for him to take the standard courses in algebra and geometry than to take other types of mathematics courses, such as general mathematics, or shop mathematics."
(2) "There is not much use in working hard with the students in general mathematics because they don't remember what you teach them anyway.
(3) "General mathematics is a course for dumbbells."
(4) "It is better to get a good grade in general mathematics than to get a low grade in algebra."
(5) "General mathematics is more interesting than regular algebra because there is more variety to the topics."

It should be understood that the writer is not at this point either agreeing or disagreeing with these statements; they are cited as illustrations only.

Additional steps in such a project might include a survey of the relevant literature to secure additional statements, and a summary of previous evaluations of beliefs on the selected issue. Unless these latter were relatively recent, however, they would need to be treated with caution because attitudes do change, and there has been slow but constant improvement in mathe-

matics courses over the years. A collection of such statements may usually be analyzed and classified into a few groups or types. Finally, a plan for changing undesirable beliefs can be worked out. This plan may involve quite different procedures for working with pupils than those which might be suitable for parents, advisors, employers, and other interested parties.

As long as large numbers of teachers, pupils, and parents agree with statements which are essentially unfavorable to general mathematics, social mathematics, multiple-track curriculums, or for that matter, any other proposal for reform, it is obvious that progress will be very slow. Although in recent years the non-academic program has seemed to be gaining strength, it can undoubtedly be shown that the bulk of personal opinion and belief still tends to be unfavorable. One must not assume, however, that "conversely" the attitudes toward the standard courses in algebra and geometry are favorable. Both experience and quantitative studies show that there is a fairly sharp cleavage of attitude toward work in mathematics. It tends to be regarded either very favorably, or very unfavorably, with relatively little "middle ground."

The sources of these attitudes are doubtless to be found very deeply rooted in the relation of education to the social class structure. It is well known that in this country one of the chief ways by which persons from the lower social classes are enabled to rise to higher social and economic levels is through education. As the Commission on Post-War Plans points out, the so-called " 'sequential courses' are rightly associated with admission to professional schools requiring technical courses, but this fact need not and should not imply disrespect for the other courses." This is the crucial issue, and it is one which must be resolved by the schools as a whole, not by departments of mathematics alone.

The attitude of the writer on this point is, I think, fairly clear. The schools must consciously undertake the task of reducing social and educational snobbishness. Teachers, pupils, and parents must be helped to see and appreciate the "dignity and worth of the common man," and the common job. Usually it is better to learn something well than it is to half-learn something more difficult or more complex. It is preferable to be a superior workman at some everyday job—even it is is only cutting grass and raking leaves—than to be a careless and undependable laborer who turns out a poor product at some supposedly "bet-

ter" kind of job. It is, I think, better to do a good job in a course in general mathematics than a poor job in a course in algebra.

The above observations suggest a second point about which a group of attitudes seems to cluster. This has to do with attitudes about good workmanship in general. Some years ago, Henry Morrison wrote at length about this in his book, *The Practice of Teaching in the Secondary School*. He attacked the "theory of the passing grade" and discussed "the get-by attitude" which it engenders. Most of what he said still makes very good sense. A great deal of what we do in schools even today is elegantly contrived to develop in students attitudes that are in the long-run unfavorable to the best results. We must remember that all the students in the high schools have, as we say, been "exposed" to arithmetic for years. They have also been exposed to the doctrine that much less than perfect work (90% accuracy, or 80%, or 70%, or even 60%) is, although not commendable, nevertheless acceptable. They have also been more or less constantly exposed to the experience of finding it is possible to complete assignments without understanding what they have done, and so gradually many of them adopt a peculiar attitude toward trying to understand. They come to believe that, for the most part, mathematics is something you learn or memorize, and that you are not supposed to be able to understand it. You just do it. One common result of such an attitude is that the pupil gives very poor attention to explanations by the teacher or text. In short, one can readily recognize a number of attitudes or beliefs which are commonly held by students about their work. As long as certain attitudes unfavorable to good work persist, many of the proposed reforms in curriculum and method will be relatively ineffective.

It is not difficult to list other points at which attitudes seem to be playing an important role. Certain proposals have been made for the improvement of the work in algebra, plane geometry, and other courses which compose the "sequential program." For example, a few years ago some aggressive teachers of mathematics took seriously a certain recommendation which was favored in the *Third Report* of the Committee on Geometry of the National Council of Teachers of Mathematics. This led them to give much more than usual emphasis to the problem of achieving "transfer" of the reasoning abilities developed in their courses and, by one means or another, to help their students associate richer meanings with important concepts and

processes. Although the majority of such efforts seemed to produce favorable results, the reaction of teachers of mathematics is far from universally favorable. It would, therefore, be of some interest to analyze the beliefs which center around the movement. Undoubtedly, some of these attitudes are overly-enthusiastic, others are unjustifiably antagonistic. In some cases, the evidence to support or contradict the belief is non-existent, and it should be regarded merely as an hypothesis to be investigated. In other cases, the holding of the attitude is logically incompatible with existing evidence—but the belief persists because of ignorance. It should be noted that the procedures for changing the belief would be quite different in these two cases.

Attitudes, favorable and unfavorable, constitute only one of a number of factors that affect progress. Quite obviously, another major stumbling block is ignorance. It usually takes years before a given set of recommendations becomes well and widely known among the group to whom they are addressed. Hence, an important consideration in post-war planning for improved mathematics programs will be the provisions for making the recommendations widely known. In the last analysis, however, the attitudes which the recommendations encounter will be the dominant factor in determining the extent, and the speed, of their acceptance.

In conclusion, the beliefs on which this paper is based may be stated as follows. With certain ends already clearly in view, we need most to discover more effective means of achieving these ends than have been used in the past. In particular, we should learn more about how to change attitudes. The hypothesis is that we will make much more rapid progress if we will: (1) identify and formulate verbally the major attitudes or beliefs which hinder authoritatively recommended changes in mathematical education; (2) plan and execute an organized approach to the problem of changing these attitudes. In short, we need to think carefully about the best methods, from the standpoint of psychology, of changing those attitudes that are unfavorable to the continued improvement of mathematical education.

True science is distinctly the study of useless things. For the useful things will get studied without the aid of scientific men. To employ these rare minds on such work is like running a steam engine by burning diamonds.

CHARLES SANDERS PIERCE in *Pierce's Collected Papers*

MATHEMATICS IN WEATHER FORECASTING

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The modern meteorologist, when actually in the process of formulating his weather forecast or when merely "keeping in touch with the weather," has before him a great number of figures and symbols representing past and present weather conditions as observed throughout the length and breadth of the country and, in peace time at least, from ships at sea. By means of an ingenious numeral code, weather observations are transmitted quickly by teletype or radio to a central office, where the message is decoded into numbers and symbols, which, in turn, are plotted on a base map of the country.

For each single station there may be a dozen or more individual entries, each representing a meteorological element, such as temperature, atmospheric pressure, type of cloud present, ceiling, etc. As a consequence, the number of individual entries on a completed map runs into the thousands. To the forecaster these numbers and symbols are particular values of variable quantities. To him the weather map is a picture of the ever-changing weather conditions. It is his problem to foretell what the picture will be like a few hours later, or the following day, or a week later, and also to describe in advance the various stages of development during the intervening period. It is a difficult problem. The forecaster must know what physical principles play a part in the bringing about of the various weather phenomena, how the variable elements are related one to another, and how changes in one or more of the variables effect a change in another.

So complex is the problem that weather forecasting is sometimes spoken of as an art rather than a science. A seasoned forecaster often finds it difficult to explain just how he arrived at his final conclusions. But it was not by guesswork. Rather it was accomplished through a series of quantitative evaluations of unknown variable quantities. Through his search for laws and principles governing the changes in the variable elements, the forecaster also has discovered quantities which remain invariant, or approximately so, during the forecast period. Many of these invariants are clothed in mathematical symbols. They may be expressed in terms of variable quantities, which, in turn, may

be related to, or dependent upon, or, using mathematical language, functions of other variable elements. It is the mathematician's dream to be able to formulate the relationships which exist among the different invariant and variable elements at hand in such a way that quantitative conclusions may be drawn therefrom with a minimum of effort and expenditure of time.

During the past few years meteorologists have been able to collect data concerning the structure of the atmosphere from the ground up to high elevations in the stratosphere. The "radiosonde," an instrument carried aloft by a balloon and which automatically transmits observations of pressure, temperature, and relative humidity at various levels in the atmosphere by means of radio, is now in use twice daily at about 80 stations in the United States, Alaska, and Canada. Pilot balloon observations are taken four times a day at about 275 stations. The pilot balloon is inflated with helium gas so as to have a prescribed "free lift." The elevations a balloon will reach at the end of successive minutes of flight under such conditions have been pre-determined, and in order to determine the speed and direction of the horizontal drift of the balloon at various levels (which is also the wind velocity in the region where the balloon is at that time), it is sufficient to observe the azimuth and the elevation angle of the balloon at the end of successive minutes and apply simple trigonometry. With more data available concerning the atmospheric structure, meteorology now has become a science dealing with atmospheric thermodynamics, statics, kinematics, and dynamics.

One interesting, but rather unfortunate, fact about the weather, however, is its complexity, and someone might scoff at the idea of applying theoretical formulas in the attempt to predict the future atmospheric structure with all its variable elements so complexly related that even the task of obtaining representative data remains a partly unsolved problem and a challenge to the ingenuity of meteorologists. In spite of this difficulty, mathematics has played an important part in modern weather forecasting in recent years. Formulas have been developed which will yield reliable results when correctly applied by the forecaster to data which are known to be fairly representative of the true conditions. But providing formulas for quantitative determinations of the probable future changes in meteorological elements is only one of the contributions of

mathematics to meteorology. Another contribution, fully as important as the one just mentioned, and one which has evolved out of mathematical investigations, is a better insight into some of the physical relationships which shape our weather. Theoretical mathematical deductions when applied to meteorological variables may yield an expression involving an integral which the investigator is unable to evaluate numerically, but which, nevertheless, gives valuable qualitative information. By means of such deductions it has been found that the horizontal temperature gradient bears a definite relationship to the vertical wind distribution in the atmosphere. Kinematical investigations have produced results giving valuable information regarding the probable future displacements of barometric disturbances and and have shown how the temperature distributions are related to such movements. The vertical wind distribution in the atmosphere is related to pressure changes aloft in such a quantitative manner that data from pilot balloon observations alone will yield valuable information regarding the time rate of change of pressure at elevations above the surface. As more and better aerological data become available, no doubt more and more of the results of mathematical investigations will find applications in meteorology.

Application of the theory of wave motion and hydrodynamics have brought about a better understanding of the complex motion of air in the atmosphere. Such thermodynamic concepts as equivalent potential temperature and specific entropy are familiar terms to the modern meteorologist. Twice a day the radiosonde operator computes pertinent data corresponding to three different "isentropic surfaces" in the atmosphere. It is along such surfaces, i.e., surfaces of constant entropy, that air motion takes place, since the motion of air in the atmosphere is mostly adiabatic until condensation and precipitation occur.

In order to be able to observe the motion of an air mass moving across the country, the meteorologist naturally looks for characteristic elements of the air mass which remain invariant as the air mass moves across the plains, up mountain slopes, and down into valleys. Ordinary elements such as temperature and relative humidity are of little value as characteristic elements, since they are too easily changed by thermodynamic processes taking place in the air mass. But here again mathematics has come to the rescue. Although the individual observable ele-

ments themselves are not invariants, a function of several of them may be. Such relationships have been found and today serve a useful purpose in daily weather analysis.

The picture of the weather situation that the modern forecaster forms in his mind is therefore a composite of the actual appearance of the weather and a number of abstract concepts embodying the dynamics as well as the statics of the weather situation. Both vector and scalar quantities are represented in this picture, and the chief problem which daily confronts the weather forecaster is that of extrapolating these vector and scalar fields into the future.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

LATE SOLUTIONS

1900. *Proposed by Mae Edwards, Syracuse, N. Y.*

If any determinant vanishes show that the minors of any one row will be proportional to the corresponding minors of any other row.

Solution by Sam P. Morgan, Jr., California Institute of Technology

Let the determinant in question be

$$A = |a_j^i| = 0, \qquad (i = 1, 2, \cdots, n; j = 1, 2, \cdots, n)$$

where a_j^i is the element belonging to the ith row and the jth column. We shall show that corresponding minors of the kth row and the lth row are proportional.

If and only if $A=0$ its rows are linearly dependent; that is, we can solve the set of n homogeneous equations

$$\sum_{i=1}^{n} \lambda_i a_j^i = 0, \qquad (j=1, 2, \cdots, n), \tag{1}$$

and get n multipliers λ_i not all of which are zero.

Case I. If $\lambda_k=0$, we can suppress the terms in (1) for which $i=k$; then we have

$$\sum_{i\neq k} \lambda_i a_j^i = 0, \qquad (j=1, 2, \cdots, n) \tag{2}$$

a set of n homogeneous linear equations in $(n-1)$ unknowns. Since (2) has a non-trivial solution in the λ's, the rank of the matrix of the coefficients of the λ's in (2) must be less than the number of unknowns, which is $(n-1)$. This implies that every determinant of order $(n-1)$ from the coefficient matrix of (2) vanishes. But the determinants of order $(n-1)$ from the coefficient matrix of (2) are just the minors of the kth row of A. Hence if $\lambda_k=0$ all the minors of the kth row of A vanish. They are (trivially) proportional to the minors of any other row, the proportionality factor being zero.

Case II. If $\lambda_k \neq 0$, we can solve (1) for a_j.

$$a_j^k = -\frac{1}{\lambda_k}\sum_{i\neq k} \lambda_i a_j^i, \qquad (j=1, 2, \cdots \; n). \tag{3}$$

Now the minor of any element a^lm of the lth row of A is just the determinant

$$a_l^m = \begin{vmatrix} a_1^1 & \cdots & a_{m-1}^1 & a_{m+1}^1 & \cdots & a_n^1 \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ a_1^k & \cdots & a_{m-1}^k & a_{m+1}^k & \cdots & a_n^k \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ a_1^{l-1} & \cdots & a_{m-1}^{l-1} & a_{m+1}^{l-1} & \cdots & a_n^{l-1} \\ a_1^{l+1} & \cdots & a_{m-1}^{l+1} & a_{m+1}^{l+1} & \cdots & a_n^{l+1} \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ a_1^n & \cdots & a_{m-1}^n & a_{m+1}^n & \cdots & a_n^n \end{vmatrix}.$$

If we substitute for each element a_j^k $(j=1, 2, \cdots, m-1, m+1, \cdots, n)$ the sum from (3), namely

$$-\frac{1}{\lambda_k}\sum_{i\neq k} \lambda_i a_j^i,$$

we can break a_l^m up into a sum of $(n-1)$ determinants each of which differs from a_l^m only in that the row

$$(a_1^k, \cdots, a_{m-1}^k, a_{m+1}^k, \cdots, a_n^k)$$

has been replaced by the row

$$\left(-\frac{\lambda_i}{\lambda_k}a_1^i, \cdots, -\frac{\lambda_i}{\lambda_k}a_{m-1}^i, -\frac{\lambda_i}{\lambda_k}a_{m+1}^i, \cdots, -\frac{\lambda_i}{\lambda_k}a_n^i\right).$$

In the different members of the sum of determinants i takes on all values from 1 to n, excluding $i=k$.

Each of these determinants for which $i\neq l$ has two rows proportional and so vanishes. The determinant for which $i=l$ is

$$\left|\begin{matrix} a_1' & \cdots & a_{m-1}' & a_{m+1}' & \cdots & a_n' \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ a_1^{k-1} & \cdots & a_{m-1}^{k-1} & a_{m+1}^{k-1} & \cdots & a_n^{k-1} \\ -\frac{\lambda_l}{\lambda_k}a_1^l & \cdots & -\frac{\lambda_l}{\lambda_k}a_{m-1}^l & -\frac{\lambda_l}{\lambda_k}a_{m+1}^l & \cdots & -\frac{\lambda_l}{\lambda_k}a_n^l \\ a_1^{k+1} & \cdots & a_{m-1}^{k+1} & a_{m+1}^{k+1} & \cdots & a_n^{k+1} \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ a_1^{l-1} & \cdots & a_{m-1}^{l-1} & a_{m+1}^{l-1} & \cdots & a_n^{l-1} \\ a_1^{l+1} & \cdots & a_{m-1}^{l+1} & a_{m+1}^{l+1} & \cdots & a_n^{l+1} \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ a_1^n & \cdots & a_{m-1}^n & a_{m+1}^n & \cdots & a_n^n \end{matrix}\right|.$$

But this last determinant is $(-\lambda_l/\lambda_k)(-)^{k-l}$ times the minor of a_m^k in the expansion of A. Hence the minors of the lth row are equal to the minors of the kth row times $(-)^{k-l+1}(\lambda_l/\lambda_k)$.

1903. *Proposed by Frank Brown, Linden, Mich.*

Find the sum to infinity of the series:

$$\frac{3}{1\cdot 2\cdot 4}+\frac{5}{3\cdot 4\cdot 6}+\frac{7}{5\cdot 6\cdot 8}+\cdots+\frac{(2n+1)}{(2n-1)(2n)(2n+2)}+\cdots.$$

A solution will be offered later. *Editor.*

1904. *Proposed by Hugo Brandt, Chicago, Ill.*

A rule is given for rectifying a small arc of a circle as follows: In a coordinate system with O as origin, draw an arc $OA=2d$, in the first quadrant with $M(O, r)$ as center. Prolong chord AO back through O to B, making $OB=\frac{1}{2}AO$. With B as a center, draw an arc AC intersecting the x axis in C. In calling $OC=$arc OA, what is the error for $2d=60°$ and for $2d=90°$.

Solution by William A. Richards, Berwyn, Ill.

In triangle B_1OC_1, $B_1O=\frac{1}{2}r$, $B_1C_1=3r/2$, and angle $B_1OC_1=150°$.
Let angle $OC_1B_1=x$, then angle $B_1=30°-x$.
By the law of sines,

$$\frac{\frac{1}{2}r}{\sin x}=\frac{3r/2}{\sin 150°}=\frac{OC_1}{\sin(30°-x)}.$$

Then

$$\sin x=\tfrac{1}{6},\quad\text{and}\quad \sin(30°-x)=\frac{\sqrt{35}-\sqrt{3}}{12}.$$

Hence

$$OC_1=\frac{\frac{1}{2}r\sin(30°-x)}{\sin x}=\tfrac{1}{4}r(\sqrt{35}-\sqrt{3})=1.0460075r.$$

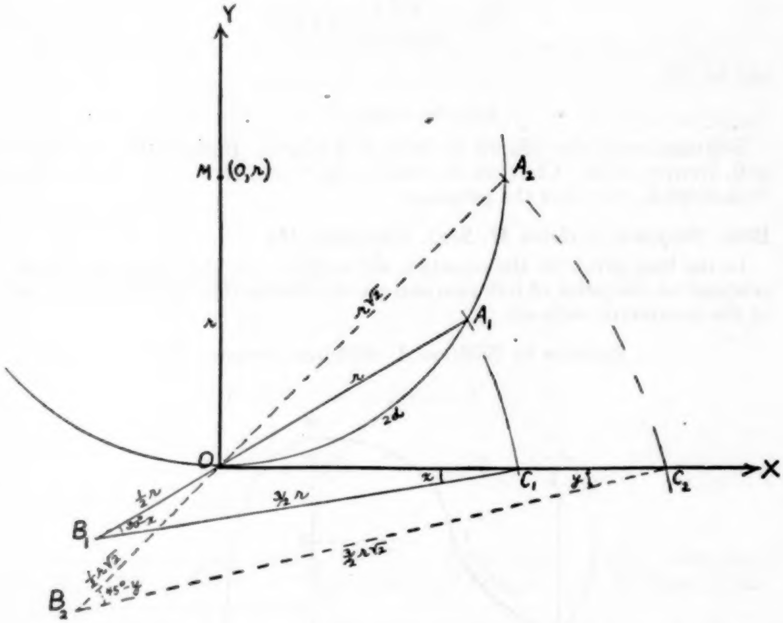
But

$$\text{arc } OA_1=2d=\frac{\pi r}{3}=1.0471975r.$$

Therefore the error for OC_1, when $2d=60°$, is $-.00119r$ (approximately).

Similarly, by using triangle B_2OC_2, we can show that the error for OC_2, when $2d=90°$, is $-.00924r$ (approximately).

(If we should choose $2d=30°$, the error is reduced to $.00002r$. Therefore, it is evident that the rule increases in accuracy as the arc of the circle decreases in size but remains positive.)



Solutions were also offered by Felix John, Philadelphia; U. Alfred, Napa, Calif.; Sam P. Morgan, Pasadena, Calif.; and the proposer.

1905. *Proposed by Helen M. Scott, Baltimore, Md.*

A focal chord of parabola $y^2=2px$, intersects the parabola in points $(9x_1, 3y_1)$ and $(x_1, -y_1)$. Find its equation.

Solution by Hugo Brandt, Chicago

The focus of the parabola

$$y^2=2px \tag{1}$$

is $F(\frac{1}{2}p, 0)$, and any line through it has the equation

$$y=A(x-\tfrac{1}{2}p). \tag{2}$$

Since this is to satisfy the points $(x_1, -y_1)$ and $(9x_1, 3y_1)$ where y_1 itself is evidently positive, we have

$$-y_1=A(x_1-\tfrac{1}{2}p) \tag{3}$$

$$3y_1=A(gx_1-\tfrac{1}{2}p). \tag{4}$$

Dividing (4) by (3):

$$-3=\frac{18x_1-p}{2x_1-p};$$

from which

$$x_1 = \tfrac{1}{6}p. \qquad (5)$$

$$y_1 = \frac{\sqrt{3}}{3}\,p. \qquad (6)$$

$$A = -\frac{\sqrt{3}\,p}{3(\frac{1}{6}p - \frac{1}{2}p)} = +\sqrt{3}. \qquad (7)$$

and by (2)

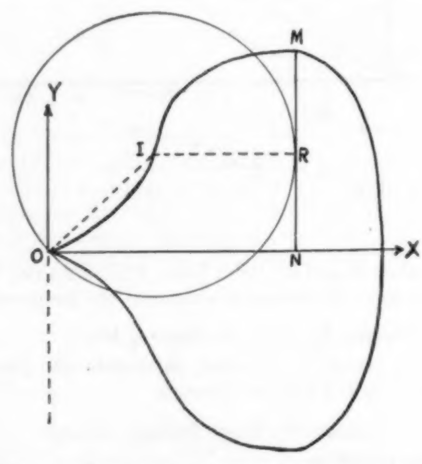
$$y = \sqrt{3}(x - \tfrac{1}{2}p).$$

Solutions were also offered by Wm. A. Richards, Berwyn, Ill.; O. Marinoff, Denver, Colo.; Clarence R. Perisho, McCook, Neb.; Bro. Felix John, Philadelphia, Pa.; and the proposer.

1906. *Proposed by Helen M. Scott, Baltimore, Md.*

In the loop given by the equation $a^2y^2 = x^3(2a - x)$, show that the circle, centered on the point of inflexion and passing through the origin, is tangent at the maximum ordinate.

Solution by William A. Richards, Berwyn, Ill.



Let I be the point of inflexion, and M be the maximum point.
Draw the maximum ordinate, NM.
Then we are to show that $OI = IR$.
The given equation is

$$a^2y^2 = x^3(2a - x) = 2ax^3 - x^4. \qquad (1)$$

Differentiating (1), we have

$$y' = \frac{3ax^2 - 2x^3}{a^2y}. \qquad (2)$$

Setting $y' = 0$ we obtain

$$x = 3a/2.$$

Hence, the maximum point is $M(3a/2,\ 3a\sqrt{3}/4)$.

Differentiating (2), we get

$$y''=\frac{x(6ay-6xy-3axy'+2x^2y')}{a^2y}. \tag{3}$$

Setting $y''=0$, we have

$$6y(a-x)-xy'(3a-2x)=0. \tag{4}$$

Substituting the value of y' from (2) in (4), and reducing, we obtain

$$6a^2y^2(a-x)-x^2(3a-2x)^2=0. \tag{5}$$

And then, substituting the value of y from (1) in (5), and reducing, we have

$$2x^2-6ax+3a^2=0. \tag{6}$$

Solving (6) for x,

$$x=\tfrac{1}{2}a(3-\sqrt{3}).$$

Hence, the point of inflexion is

$$I\left[\tfrac{1}{2}a(3-\sqrt{3}),\ \tfrac{1}{2}a\sqrt{6\sqrt{3}-9}\right].$$

Then

$$OI=\sqrt{\tfrac{1}{4}a^2[(12-6\sqrt{3})+(6\sqrt{3}-9)]}=\tfrac{1}{2}a\sqrt{3}.$$

Also

$$IR=3a/2-\tfrac{1}{2}a(3-\sqrt{3})=\tfrac{1}{2}a\sqrt{3}.$$

Therefore $\qquad OI=IR.$

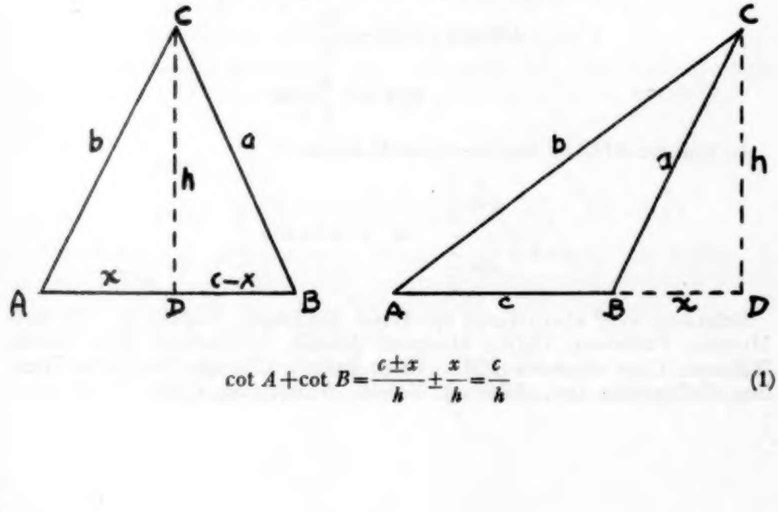
Solutions were also offered by U. Alfred, Napa, Calif.; Marcellus Dreiling, Collegeville, Ind.; Hugo Brandt, Chicago; Sam Morgan, Pasadena, Calif.; and the proposer.

1907. *Proposed by Lillie Marsh, Romulus, N. Y.*

For triangle ABC, show by geometry (if possible) that

$$\cot A+\cot B=\frac{c^2}{ab\sin C}.$$

Solution by O. Marinoff, Denver, Colo.



$$\cot A+\cot B=\frac{c\pm x}{h}\pm\frac{x}{h}=\frac{c}{h} \tag{1}$$

$$\text{area } \triangle ABC = \frac{ab \sin C}{2} = \frac{hc}{2}, \quad \therefore \ h = \frac{ab \sin C}{c}$$

subst. in (1)

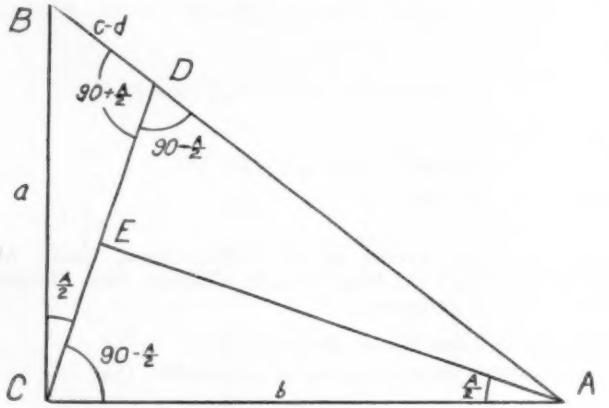
$$\cot A + \cot B = \frac{c^2}{ab \sin C}.$$

Solutions were also offered by U. Alfred, Napa, Calif.; Dorothy C. Hand, Clark's Summit, Pa.; Mary Paula, Baltimore, Md.; Sam Morgan, Pasadena; Felix John, Philadelphia, Pa.; Aaron Buchman, Buffalo, N. Y.; Edith M. Warne, Marshall, Mo.; Marcellus Dreiling, Collegeville, Ind.; W. R. Warne, Marshall, Mo.; Alan Wayne, Flushing, L. I., New York, N. Y.; Hugo Brandt, Chicago; Wm. A. Richards, Berwyn, N. Y.

1908. *Proposed by Edith M. Warne, Marshall, Mo.*

In any right triangle ABC prove $c-b=a \tan A/2$.

Solution by Clarence R. Perisho, McCook, Neb.



Lay off $AD=b$, then $BD=c-d$.
Construct $AE \perp DC$. AE then bisects $\angle A$.

$$\angle BCD = \angle CAE = \angle \frac{A}{2}$$

$$\angle BDC = \angle \frac{A}{2} + 90°.$$

In triangle BDC by the sine formula we have

$$\frac{a}{c-b} = \frac{\cos \frac{A}{2}}{\sin \frac{A}{2}} \quad \text{or} \quad c-b = a \tan \frac{A}{2}.$$

Solutions were also offered by Aaron Buchman, Buffalo, N. Y.; Sam Morgan, Pasadena, Calif.; Margaret Joseph, Milwaukee, Wis.; Grace Williams, Cape Girardeau, Mo.; Hugo Brandt, Chicago; Marcellus Dreiling, Collegeville, Ind.; Albert J. Nelson, Wilmington, Calif.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below.

1907. *Richard Major, Union School, Honesdale, Pa.*

1908. *Richard Major, Frank L. Frailey and Vivian Smith—all of Union School, Honesdale, Pa.*

The editor regrets that due to war time restrictions a copy of the magazine can not be sent to each student of a high school offering a solution. It is to be hoped however that contributions will be sent for the honor roll.

PROBLEMS FOR SOLUTION

1921. *Proposed by Julius Miller, New Orleans, La.*

A chain L feet long, suspended by its upper end, is allowed to drop from its position of rest. How long does it take it to pass a point D feet below the point of suspension?

1922. *Proposed by Benjamin Sedlezky, Montreal, Canada.*

A baseball game may be won, lost or result in a tie. If eight games are played and one attempts to predict the results, in how many different ways can exactly six correct results be given?

1923. *Proposed by Julius S. Miller, New Orleans, La.*

A juggler keeps three balls going with one hand, so that, at each instant, two balls are in the air and one is in his hand. If the time during which each ball stays in his hand is one-half second, show that each ball rises to a height of four feet.

1924–5. *Proposed by a Student.*

Resolve into linear factors, not necessarily real, the determinants:

$$\text{(a)}\quad \begin{vmatrix} a & b & c & d \\ b & a & d & c \\ c & d & a & b \\ d & c & b & a \end{vmatrix} \qquad\qquad \text{(b)}\quad \begin{vmatrix} a & b & c & d \\ d & a & b & c \\ c & d & a & b \\ b & c & d & a \end{vmatrix}.$$

1926. *Proposed by Howard D. Grossman, New York, N. Y.*

Prove: In 4-place tables $\log_{10} \log_{10} e$ differs by 10 points from its neighbors, and $\log_{10} (K \log_{10} e)$ differs by $10/K$ points from its neighbors.

BOOKS AND PAMPHLETS RECEIVED

METEOROLOGY, A PRACTICAL COURSE IN WEATHER, by George J. Brands, *Chief Meteorologist, Pan American Airways System.* Cloth. Pages viii+235. 14×22.5 cm. 1944. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 18, N. Y. Price $2.50.

ALIGNMENT CHARTS, By Maurice Kraitchik, *Professor of Mathematics, New School for Social Research, New York.* Cloth. 94 pages. 15×23 cm.

1944. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $2.50.

SENIOR MATHEMATICS, by Harl R. Douglass and Lucien B. Kinney. Cloth. Pages x+437. 13×20 cm. 1945. Henry Holt and Company, Inc., 257 Fourth Avenue, New York, N. Y. Price $1.52.

METALS AND ALLOYS DICTIONARY, by M. Merlub-Sobel, Ph.D. Cloth. Pages v+238. 13.5×21.5 cm. 1944. The Chemical Publishing Company. Inc., 234 King Street, Brooklyn, N. Y. Price $4.50.

CONSIDER THE CALENDAR, by Bhola D. Panth, Ed.D. Paper. 138 pages. 15×23 cm. 1944. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $1.25.

BETTER COLLEGES—BETTER TEACHERS, by Russell M. Cooper and Collaborators of 28 Colleges. Published by the North Central Association Committee on the Preparation of High School Teachers in Colleges of Liberal Arts. Paper. Pages viii+167. 15×23 cm. 1944. Distributed by the Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.25.

EDUCATION IN CONSERVATION OF OUR NATURAL RESOURCES, by Dr. Henry Baldwin Ward and Others, University of Illinois, Urbana, Ill. Paper. 31 pages. 15.5×23 cm. 1944. Price 10 cents.

REPORT OF THE PRESIDENT OF COLUMBIA UNIVERSITY FOR 1944. Paper. 64 pages. 15×23 cm. Columbia University, Morningside Heights, New York 27, N. Y.

DIGEST OF INVESTIGATIONS IN THE TEACHING OF SCIENCE 1937–1943, by David J. Blink, *Instructor in Chemistry, University of Connecticut, Storrs, Conn.* Paper. 108 pages. 21.5×28 cm.

TWENTY-FIVE YEARS OF RADIO PROGRESS WITH RCA. Paper. 87 pages. 21.5×28 cm. 1944. Radio Corporation of America, New York, N. Y.

EDUCATION A MIGHTY FORCE—ITS ROLE IN OUR FUTURE, issued by the National Education Association. Paper. 16 pages. 21.5×28.5 cm. National Education Association of the United States, 1201 16th Street, Northwest, Washington 6, D. C.

BOOK REVIEWS

SHOP JOB SHEETS IN RADIO, BOOK I—FUNDAMENTALS. Paper. Pages iii+134. BOOK II—SERVICE PROBLEMS. Paper. Pages vii+128. By Robert Neil Auble, B.S., A.B., *Instructor in Radio, Arsenal Technical Schools, Indianapolis and Supervisor, Signal Corps Radio School, Indianapolis.* 1944. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.50 each.

These two books are designed to help students obtain the practical knowledge necessary for an understanding of the fundamentals of radio and practice in service problems. The first sheet gives directions for making electrical connections—a complete and thorough lesson on soldering, types of solder, fluxes, connections, insulation, and care of the soldering iron. Eight solder jobs are to be done with two optional jobs for the faster students. These are followed by questions to be answered in script by the student. Definite references to standard books accompany the directions.

In this manner each of the thirty job sheets in Book I and the twenty-five job sheets in Book II is carried through. Book I guides the student through the study of electrical diagrams, magnetic phenomena and uses, the fundamental ideas of electrical measurement of direct currents, induced currents, the transformer, wire gauges, coil winding, building a crystal set, capacitance, construction of an audio oscillator, and the action of a rectifier tube. If a student carries out the shop work outlined and makes a careful study of the references given in the six or eight reference books listed, he will have acquired a fairly complete working knowledge of the fundamentals of radio.

Book II is devoted to service problems. It consists of four fundamental types of jobs: (a) a study of the basic parts, resistors, condensers, transformers, inductors, and vacuum tubes; (b) four test sheets on constructing and testing of power supply and amplifiers; (c) nine sheets covering completely the construction and use of the various parts of the superheterodyne receiver; (d) seven sheets on the transmitter consisting of a job sheet on each of the following: the Hartley oscillator, the electron-coupled oscillator, the quartz-crystal oscillator, radio frequency amplifiers, frequency doubler circuit, the power supply, and modulation. Four or five additional reference books and catalogs from leading supply houses are listed for definite study. The student who really masters the work of these two courses will be well prepared for radio servicing in either military or civilian work.

G. W. W.

THEY HOP AND CRAWL, by Percy A. Morris, *Peabody Museum of Natural History, Yale University, New Haven, Connecticut.* Cloth. Pages—Introduction+253. 15×23 cm. 1944. The Jacques Cattell Press, Queen Street and McGovern Avenue, Lancaster, Pennsylvania. Price $3.50.

This is one of the Humanizing Science Series published by the Cattell Press. The author is chief preparator on the staff of the Peabody Museum of Natural History of Yale University. He has contributed many articles to popular magazines on nature subjects as well as being a recognized authority in his field. The book has for its avowed purpose that of acquainting the layman as well as the amateur and professional collector with facts concerning perhaps the most generally feared and most maligned groups of animals—the reptiles and amphibians. While a number of these animals rightly deserve this classification, it might be said that the author's purpose is to make very clear that "all generalizations are false" and that it is wrong to condemn all the hopping and crawling forms because of the few that really are inimical to man's best interests.

After an introductory chapter on Snake Fallacies, Mr. Morris begins an extensive discussion of each species, giving in nontechnical language the diagnostic markings, limits of size, distribution, food habits, habitat, reproductive habits and other interesting facts, many of which he has acquired from actual experience. He has kept many of these animals in captivity and his discussions include suggestions which he has learned from his experience for successful rearing of many of them. Written in an interesting style, this book includes descriptions of 172 species with excellent photographs of 75 taken by the author, many having been photographed several times to show different views or to illustrate other points about them.

It seems to the reviewer that in our efforts to be non-technical in the writing of books of this sort we sometimes sacrifice ease of determination of a species. While this book is easily read, I believe simple artificial keys could have been included without adding too many pages. While these

might appear formidable to the uninitiated if placed at the head of each chapter, they might have been placed at the end. As one finishes each chapter one is likely to feel a bit bewildered at the wealth of detail about each species and many people would welcome, I am sure, a summary to bring out the salient facts for identification purposes. While excellent keys exist for those interested in the more technical details, even the amateur wants first of all to tack a name onto the specimen he has and usually he does not want either to go into too much detail or to re-read too many pages of textual material. This, then, would be my only criticism of an otherwise excellent and informative book on a group of animals too much misunderstood by the average person.

A criticism which should probably be directed to the publishers is an unusual number of typographical errors.

Howard F. Wright

20th Century Engineering, by C. H. S. Tupholme. Cloth. Pages xi+201. 22.5×14 cm., 1944. The Philosophical Library, New York City.

The preface states that the aim of the book is "to record, primarily for the benefit of the layman, some of the more spectacular engineering progress of the past few years." To meet the aim, the author has chosen a relatively few achievements which he describes in some detail. The fields of Mechanical Power, Engineering Workshop Processes, Air Conditioning and Refrigeration, Chemical and Metallurgical Engineering, Electrical Engineering, Traction, Marine Engineering, Aircraft, and Physics are represented.

Although the book in intended for laymen, only those with some engineering background can appreciate the significance of many recent contributions under discussion. The American layman is under another handicap because the author refers usually to English and Continental practices.

The war quickly outmoded the chapter on Aircraft, which was written when the P-38 was still a "hush-hush" topic. Other chapters, written before the war or in its early part, are not so dated.

Walter A. Thurber

Celestial Navigation. A Problem Manual, by Walter Hadel, M.A. *First Navigator and Chief Navigation Instructor, United Air Lines.* Cloth. Pages xiii+261. 13×21 cm. 1944. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $2.50.

The present global war has placed increased emphasis on the need and usefulness of a knowledge of the principles and applications of celestial navigation. The common opinion of the past has been that the use of observations on celestial bodies for navigation required the knowledge of spherical trigonometry. This would be true had not those versed in spherical trigonometry prepared tables and charts that reduce the solution of the spherical triangle to a routine and familiarity with the available charts and tables.

The book at hand has been prepared with the idea of familiarizing the would be navigator with the handling of the observations, making the necessary corrections, so that available tables may be used for the solution of the problem. This is accomplished by the presentation of each phase of the problem in the form of a quiz which consists of questions and problems. To assist the student, the principles of the topic covered in the quiz are first covered in explanatory notes and then the solutions to some of the problems are given; the remainder are left for the student to work out. The quizzes start with the simpler phases of the navigation problem and pro-

ceed to the more complicated. Practical esperience is given in the use of the three most up-to-date methods of solution; namely, H.O.214 Tables, Weems' Star Altitude Curves, and H.O.211 Tables.

The book may serve as a text in celestial navigation or as a supplementary problem manual in connection with other texts. It includes sufficient portions of the Air Almanac and the necessary tables and charts for the solution of the problems given.

H. R. Voorhees
Wilson Junior College

Learning to Navigate, by P. V. H. Weens, *Lt. Commander, U.S.N. Retired*, and William C. Eberle, *Lt. Commander, U.S.N.R.* Cloth. Pages viii+135. 14×23.5 cm. 1943. Pitman Publishing Corporation, 2 West 45th Street, New York, N. Y. Price $2.00.

This is a new edition of an earlier text in which the authors have brought the fundamentals of navigation up to date and have added material that makes this a good fundamental text for the beginner in navigation, either marine or air. The principles of navigation are first given and applied to marine problems, but later chapters have been added that apply these principles to the problems of air navigation and give the further principles and techniques needed by the air navigator.

The book is written for the beginner in navigation, and should be found useful for either selfstudy, or as a text in secondary schools or in any group wishing to learn navigation in preparation for the present war need, or for a postwar vocation, or avocation, either marine or aerial. The applications of the principles are well illustrated with diagrams and charts. The instruments used in navigation are also well illustrated. Worked out problems, with additional questions and problems for each chapter, make the text especially suitable for selfstudy.

The chapters on celestial navigation give the necessary readings and corrections necessary to be able to use the available tables and charts for the solution of the celestial triangle. Methods of solution are pointed out and should serve as an excellent step to the more detailed study of celestial navigation.

A bibliography for more advanced study is given at the end of the book, along with a listing of sources of information and materials for navigators.

H. R. Voorhees

Fundamental Mathematics, by Raleigh Schorling, *Head of the Department of Mathematics in the University High School in the University of Michigan*; John R. Clark, *Professor of Education, Teachers College in Columbia University;* and Rolland R. Smith, *Specialist in Mathematics in the Public Schools in Springfield, Massachusetts.* Book I. Pages xiii +368. Cloth. 1944. World Book Company, New York, N. Y. Net wholesale, $.75.

This is a seventh grade arithmetic book well written by men who have a sound background of knowledge and experience. This text starts with measure, the logical use of number, and thereby opens the way for meaningful operations rather than mere manipulation. Accuracy and precision are discussed and applied. Throughout the text sufficient history of the development of our number system is given to add more meaning to it.

The text is written from a practical viewpoint where estimates and quick solutions are needed as in everyday arithmetic solutions. The teacher will find in this book a large amount of practice material with cumulative re-

views. A change of emphasis is noted in the lack of advanced social problems such as taxes, stocks and bonds, etc. The emphasis is on need as seen by the seventh grade pupil in his activities. The topics covered besides measurement are: our number system, everyday problems, graphs, per cents, geometry in design and a short unit on communication.

Understanding is the objective throughout with ample material for discussion and generalization. The test will fit into almost any series because the reviews are complete. Many texts are provided as well as supplemental material. The mechanics of the book are excellent, easy to read with excellent pictures on mathematics at work.

PHILIP PEAK
University School
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FUNDAMENTAL MATHEMATICS, BOOK 2, by Raleigh Schorling, *Head of the Department of Mathematics in the University High School in the University of Michigan;* John R. Clark, *Professor of Education, Teachers College in Columbia University;* and Rolland R. Smith, *Specialist in Mathematics in the Public Schools in Springfield, Massachusetts.* Pages xiii+402. 1944. World Book Company, New York, N. Y. Cloth. Net wholesale $.81.

This is an eighth grade arithmetic text written by men who know their subject and have had wide experience in teaching the field. This text shows the change in emphasis in grade eight. The only algebra found is that in connection with the formula where a few simple equations are given. As in book one the first unit is on the age of measurement and precision. This leads the pupil to recognize the importance of measure and the true meaning of measurement with a particular instrument. The metric system is given a place with emphasis on recognizing lengths in the metric system rather than conversion to other types of measure. Per cents are included with work on those larger than 100. There is a great deal of problem and test material on the subject. Evaluation of formula holds an important place. However the authors after building up a meaning of precision tell the student what value to use for pi in problems dealing with circumference, etc. This text includes some geometric ideas of size, shape, angle measure and simple constructions they need in scale drawing or indirect measure. A new addition in this area are three pages of spherical geometry on parallels of latitude and longitude.

The business arithmetic composes only a small part and in many cases is only a place for application of principles learned. An exception to this is: the use of the bank by an individual and consumer arithmetic. Both of these go into detail about an individual's personal affairs. The teacher will find plenty of practice material, cumulative reviews and tests.

The mechanics of the book are excellent, it is easy to read, with many photographs of real situations in which mathematics is being used.

PHILIP PEAK

PRE-SERVICE COURSE IN MACHINE SCIENCE, by Samuel H. Lebowitz, *Chairman of Science Department, Straubenmuller Textile High School, New York City.* 14.5×22 cm. Pages vi+440. Price $1.96. Published by John Wiley and Sons, New York. 1943.

Machine Science is a book written especially for pre-induction training, and as such it is a book, like others, which had to be written without giving the author much time or opportunity to use his own ideas or ingenuity. The book therefore presents the required topics in a manner which is not materially different from that used in standard High School Physics texts. The

author has however given much special attention to the application of fundamentals to the Machines used in modern warfare. He is to be complemented on his effort in this direction. The photographs are timely and well chosen. This is the case with the very good diagrams. The text does not treat Heat separately but deals with the subject as one aspect of Machines which is important in understanding their operation.

The writer finds little in the way of faults if so they can be called. It is a question whether the term "Balance" should be used interchangeably with the term "Equilibrium." The writer thinks they should not be so used but it is a matter of private opinion. Under topic 125 entitled, "Air Weight and Pressure," the author points out clearly that the air in a room 12 by 15 by 9 feet would weigh 135 lbs. He might have added something worthwhile to call attention to the fact that the total pressure (Force) on the floor of this same room is more than 150 tons. The book is remarkably free from typographical and errors overlooked by the proof reader.

At the end of each section is found a list of pertinent questions and problems. The questions are treated as devices to aid the student in finding out what he knows, and the problems are treated as a device for the student to find out how well he can use what he knows. This is a neat educational scheme to help the student and the teacher find out what aspect of the subject is not being understood.

H. H. Siemers
Shortridge High School
Indianapolis, Indiana

Analytic Geometry, by K. B. Patterson and A. O. Hickson, *Instructors in Mathematics, Duke University*. Cloth. Pages x+184. 13×20 cm. 1944. F. S. Crofts & Co., New York, N. Y. Price $2.00.

This book contains the essentials of a course in analytic geometry arranged in such a manner that it may be presented in about fifty class periods. The shortening of the course is accomplished by arranging the material to permit rapid progress, and by omission of material not essential. The omissions are accomplished by omitting entire chapters, rather than by shortening explanations or by omitting parts of chapters. The usual chapters on higher plane curves and on empirical equations are omitted from this text.

The first fifty-nine pages of the book contain the usual introductory material, graphs of equations, and equations of loci. This is followed by chapters on the circle and conic sections. In introducing conic sections the authors discuss and illustrate a right circular cone, and define ellipses, hyperbolas, and parabolas as sections of the cone. Then analytic definitions of the three curves are given, and methods of point by point construction of the curves are given. Following the discussions of the curves, each curve is proven to be a section of a right circular cone. The chapter on translation and rotation of axes includes a discussion of invariants. The invariant b^2-4ac is the only one of which extensive use is made. A chapter on polar coordinates includes intercepts, symmetry, and extent of polar curves, and the polar equation of conics. The chapter on parametric equations includes trajectories, roulettes, and the involute of a circle. The delta notation and limits are used in the study of tangents and normals. The work on geometry of three dimensions is brief but includes equations of planes, lines, and second degree surfaces.

There seems to be enough exercises in the text, but a bright student might work all of them. In several places a large amount of theory is given between lists of exercises. There are many good features in this text such as

the chapter on loci of euqations and on tangents and normals. The discussions are brief and clear. Good drawings and well arranged pages add to the value of the text. This text is recommended to instructors offering a short course in analytic geometry.

HILL WARREN
Lyons Township Junior College
LaGrange, Ill.

EDUCATORS GUIDE TO FREE FILMS, Fourth Edition, Compiled and Edited by Mary Foley Horkheimer; and John W. Differ, M.A., *Visual Education Director, Randolph High School, Randolph, Wisconsin. Educational Consultant,* John Guy Fowlkes, Ph.D. Paper. Pages 201. 21.3×27 cm. 1944. Educators Progress Service, Randolph, Wisconsin.

In their Fourth Edition of the "Educators Guide to Free Films," Mary Horkheimer and John Differ have again arranged a useful compendium of information for the user of visual aids.

The new edition is further distinguished by a short treatise on "Audio-Visual Aids to Learning" by Dr. John Guy Fowlkes. These introductory remarks should prove a springboard to intelligent visual aids activity on the part of the neophyte—as well as providing up-to-date information on the field for the established visual educator.

The remaining 192 pages of the "Educators Guide to Free Films" comprise a comprehensive index to 2165 films. 212 new titles appear in this Revised Edition—with discontinued titles being deleted. Motion picture offerings are listed alphabetically and by subject matter classification; strip or sound-slide films by subject matter classification only. Conditions of loan are clearly set forth in the index of film sources. In short, the 4th Edition seems to be practically fool-proof and should—like its predecessors—prove a valuable addition to visual aids information.

R. E. SCHREIBER
Stephens College

SWING MUSIC AND MARCHING AIRS USED BY AIRLINE TO TRAIN COMMUNICATIONS STUDENTS

Music now helps train airline communications operators by helping them to master the rhythm, accuracy and speed necessary to operate teletype machines. Anyone familiar with typing can operate a teletype machine with practice, but the teletype requires a different touch than a typewriter and is geared for a set speed, usually 65 words a minute. Teletype communications equipment must be operated in rhythm to attain speed and accuracy.

"To help the beginner attain a definite rhythm pattern, music appeared to be the logical development," D. I. Peterson, United Air Lines Supervisor of communications training, stated.

Daily practice sessions during the seven-week training course are accompanied by amplified recorded music. March tunes have been found best for improving speed, although records such as Frankie Carle's piano version of "Sweet Lorraine" provide an appropriate tempo for beginners.

An average of 20 girls are enrolled in each class studying radio, leased wire procedures, meteorology, weather reporting, and other subjects.

Upon graduation, these girls go to work transmitting weather data, operations information controlling the schedules and flights of the airline, and reservations details.